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THE OFFICIAL ORGAN OF THE BRITISH FOUNDRYMEN'S ASSOCIATION.

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BRITISH FOUNDRYMEN'S ASSOCIATION.

At the Conference held in Glasgow on August 7, 8, and 9, the two following papers were read :—

FIRECLAYS AND MOULDING SANDS.

By Percy Longmuir.

An ordinary definition of a refractory material is that of a substance capable of resisting heat. In this sense refractory materials of the foundry are to be found in furnace linings and moulding sands. Both have high temperatures to resist, though they play essentially distinct parts in the production of castings. As every stage in the process of making castings is of interest to our Association, it may not be altogether wasted time if a few moments are devoted to the more salient features of furnace linings and moulding sands. Taking first the temperatures that linings or sands have to meet, a matter of some difficulty is found in giving exact furnace measurements. However, the following approximate temperatures show the range usual in foundry furnaces :—

	Deg. Cent.
Crucible for brass	1,200 to 1,400
Air furnace for brass	1,200 to 1,400
Cupola for iron	1,500 to 1,600
Air furnace for iron	1,550
Crucible furnace steel ...	1,650 to 1,700
Open-hearth furnace	1,700 to 1,800

Mould temperatures vary, but under normal conditions will be found as follows :—

	Deg. Cent.
Aluminium	690
Brazing metal, 90-10	1,080
Yellow metal, 70-30	1,020
Ordinary casting brass, 58, 40, 2 ...	970
Gun metal, 88, 10, 2	1,070
White cast iron for malleable ...	1,230
Grey cast iron	1,350
Pure iron, 0.08 per cent. carbon ...	1,650
Steel, 0.3 „ „ ...	1,600
„ 0.37 „ „ ...	1,550
„ 0.5 „ „ ...	1,500

These tables show the higher range of furnace temperatures, and give an index as to one essential requirement in both linings and sands. Chemically, refractory materials vary, but usually contain silica, alumina, lime, magnesia, oxides of iron, or manganese, alkalies, soda and potash, etc. Silica, alumina, or lime, are alone very infusible, and will resist the highest temperatures attainable in foundry practice. However, for various reasons these materials cannot be used in a state of purity. The softening point of silica may be taken as about 1,830 degrees C.; alumina and lime are probably higher. But the three compounds which separately are extremely infusible may, on admixture, become more fusible. Boudouard, who has examined this matter from the point of view of slags, has arrived at a series of interesting results. Thus, silica softens at 1,830 degrees; if this silica is associated with 14½ per cent. alumina, the softening temperature is reduced to 1,690 degrees. Further increments of alumina and corresponding decrease in silica results in gradually raising the softening temperature, until at 37 per cent. silica and 63 per cent. alumina a softening point of 1,890 degrees is reached, which is some 60 degrees *above* that of silica. Mixtures of silica and lime—which give rise to silicates of lime—vary as follows :—

	Silica.	Lime.	Deg. Cent.
	100 ...	— ...	1,830
	86.5 ...	13.5 ...	1,780
Steadily falls ...	60.4 ...	39.6 ...	1,400
Then rises to ...	8.9 ...	91.1 ...	1,515

It will be noted that these silicates of lime are comparatively fusible—a remark also applicable to aluminates of lime. Triple combinations of silica, alumina, and lime (alumino-calcic silicates) give very fusible bodies, as, for instance :—

SiO_2.	Al_2O_3.	CaO.	Deg. Cent.
37.4 ...	10.32 ...	52.28 ...	1,380
40.0 ...	22.7 ...	37.3 ...	1,345
41.2 ...	28.1 ...	30.7 ...	1,370

These softening temperatures are well below some of the mould temperatures already given. From the foregoing it is evident that whilst certain combinations of silica and alumina may, from

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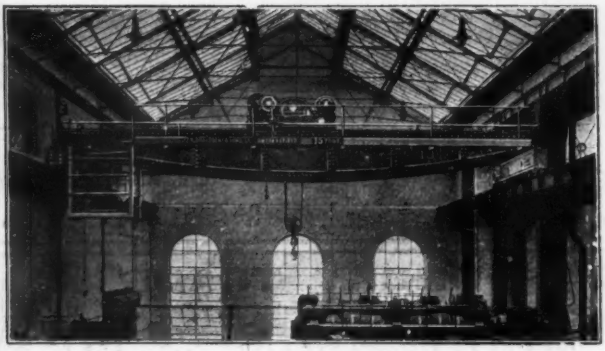

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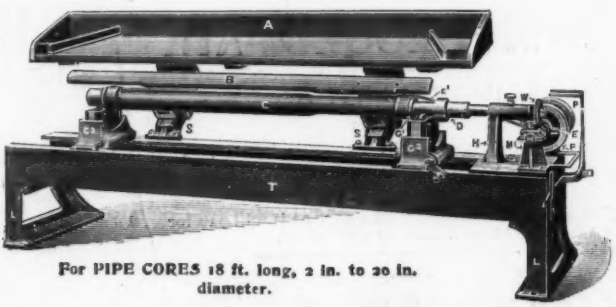

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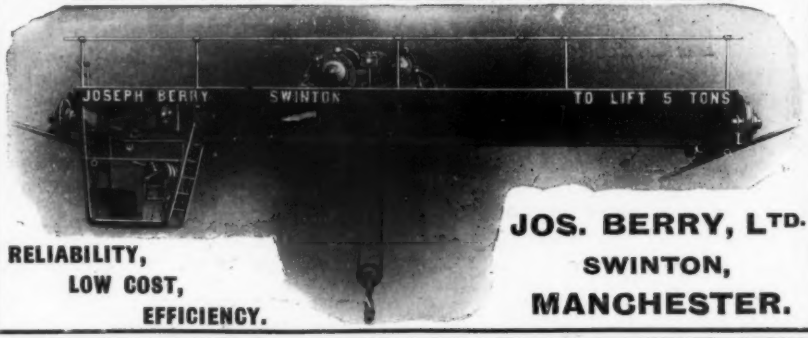

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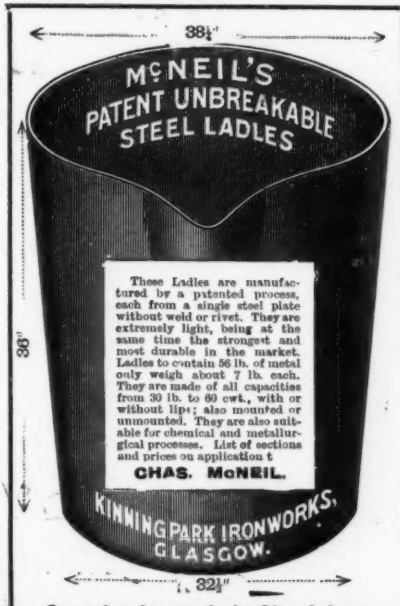
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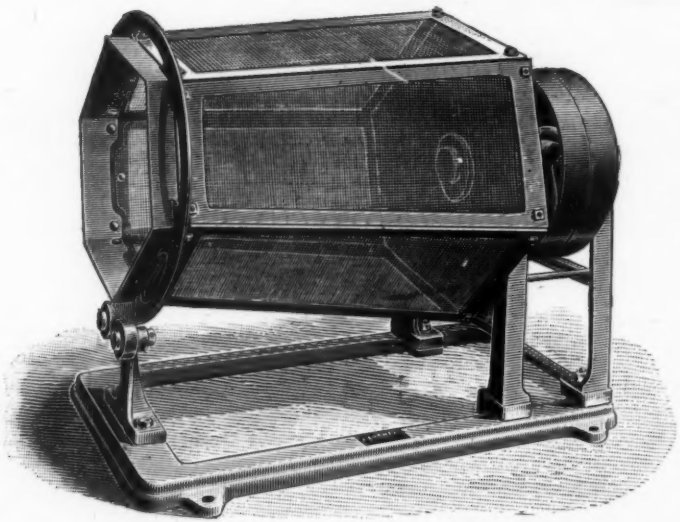

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the point of fusibility, make good refractory materials, it is also equally evident that combinations of lime with alumina or silica are not so desirable. However, this resistance to heat is only one of the many attributes which a furnace lining or a moulding sand should possess. Furnace linings have, in addition to high temperatures, to resist one or more of the following conditions :— (1) Expansion and contraction, due to alternate heating and cooling; (2) the cutting action of flames, the abrading effect of molten metal, and the searching action of metallic oxides or scouring slags; (3) reducing or oxidising atmospheres in the furnace; (4) mechanically the lining must withstand the wear and tear of charging solid metal. With regard to the action of slags, we have already seen that silica and lime, when in contact at elevated temperatures, unite and form a silicate which fuses at a comparatively low temperature. Therefore, if the lining of the furnace is siliceous and the slag contains much lime, this lime will unite with a portion of the silica of the lining and form a fluid slag. On this fact, refracting materials are grouped into three classes of :—

I. Acid. II. Neutral. III. Basic.

Acid materials contain an excess of silica which, acting as an acid, will combine with various bases to form a fusible silicate. Pure silica is extremely refractory, and is found in nature chiefly in the form of quartz, flint, etc. The nearest approach to purity in samples commercially used is that of "silica sand" or Belgium white sand, average samples of which contain :—

	Per cent.	
From	94 to 96	Silica.
,, ...	0 to 1	Ferric oxide.
,, ...	0 to 2	Alumina.

and traces of lime and magnesia.

This sand is very infusible, and it is used for forming the bed of the open-hearth furnace. The hearth portion of such a furnace is usually formed of a boiler plate shell, lined with firebrick, then a course of silica brick, and the basin formed by spreading even layers of white sand until the required contour is obtained. Each successive layer is "fritted," that is, the temperature is maintained until it forms a compact mass. Should the fusibility of the sand be such that it will not "frit" at the furnace temperature—the white sand is diluted by mixing with it from 5 to 10 per cent. of red sand. This addition of red sand raises the content of iron oxide, thereby rendering the mixture more fusible. Silica sand possesses no "bond," that is, it cannot be rammed into a given shape—neither can it be manufactured into brick without admixture. On the other hand, Gannister—an essentially siliceous material—contains sufficient clayey matter to permit of the ground material being moulded into any required form. Geologically, Gannister is a fine-grained sandstone containing no mica, and, therefore, possessing no cleavage. Chemically, it varies within the following limits :—

Silica	87 to 95
Alumina	4 to 5
Ferric oxide	0 to 1.5
Lime and magnesia	0.25 to 0.75
(Soda and potash) Alkalies	0 to 1.00

Best Yorkshire samples contain 95 per cent. silica. After mining, Gannister is reduced to a coarse powder, and in certain cases lime cream is added during grinding. This addition is in all cases kept within low limits, and is only made when the material is deficient in binding qualities. Ground Gannister—mixed with a requisite quantity of water—can be used in any form of furnace construction which will permit of the material being rammed around a pattern. Examples are iron melting cupolas, Bessemer converters, and crucible steel melting holes. The last are oval in section, and are rebuilt once a month. Apart from lining in the manner indicated, Gannister is an excellent patching material, and in this manner is used as a daubing for worn places. Ground Gannister is also moulded into bricks or other furnace sections—which, on burning, are commercially known as "silica bricks." Moulding sands are, strictly speaking, acid materials, but their consideration will be delayed for a few moments. To a limited extent, various siliceous rocks are used in furnace construction. Varieties of granite and millstone grit are refractory, but tend to split on attaining high temperatures. Sandstones especially must be bedded in the plane of their stratification. Exfoliation is the chief difficulty in adapting rocks as found in nature for direct furnace construction.

Turning to the third class of refractory materials—comprised under the general term basic—we find that members of this group do not meet with a very extensive adoption in foundry practice. Although basic linings resist very high temperatures, they are not so easy to manipulate as are the acid linings. Consequently a

basic lining is only used when the slags of the process are of such a character that they eat into or unite with an acid lining. Thus in the basic process of steel-making the elimination of phosphorus depends on obtaining a strongly basic slag. Naturally these slags vary in composition during the steel-making process, but the final or finishing slag will contain, approximately :—

	Per cent.
Silica	13
Lime	46
Oxide of iron	16
Oxide of manganese	8
Magnesia	5
Phosphoric acid	12

In comparison with this, an average slag from an acid steel-making process will contain from 50 to 56 per cent. silica. These essential differences in the two types of slag determine the character of the lining. Thus, if the slag is highly siliceous, the process must be conducted on an acid hearth. On the other hand, if the slag is high in lime, a basic hearth must be used, the reason lying in the fact that, whatever the type of slag, the lining must be such that chemical combination will not occur. Such combination—as, for instance, between lime and silica—results in the formation of fusible silicates—a feature already noted in connection with softening temperatures. Commercially, basic materials are comprised in lime and magnesia, or combinations of the two. Crucibles of lime may be used for the fusion of platinum. (solidifying point of platinum, 1,780 degrees C.). However, owing to the tendency of lime to become hydrated—and consequently to disintegrate—it cannot be extensively used in furnace construction. Magnesia, in the form of crucible or brick, will resist high temperatures, but is costly. The source of magnesia lies in magnesite, which contains, when pure : Magnesia, 48.73 per cent.; carbonic acid, 51.27 per cent. Impurities are lime, silicates of iron, and free silica. Dolomite, or magnesian limestone, is a double carbonate of lime and magnesia. It contains : Carbonate of lime, 54.35 per cent.; carbonate of magnesia, 45.65 per cent. Dolomite, after mining, is calcined at high temperature, ground to a powder and mixed with anhydrous tar. Tar is used as a binding agent—when the material is to be rammed directly on a furnace hearth—or pressed into brick. In the latter case the completed bricks are externally coated with tar to prevent the absorption of atmospheric moisture, and so disintegrating. A further basic material is found in bauxite, which is a hydrated ferric aluminate, and is applied in a similar manner to dolomite. In composition, it varies between the following limits :—

Alumina	50 to 60
Ferric oxide	10 to 25
Silica	3 to 5
Water	10 to 15

In passing, it may be well to note that bauxite is an aluminium ore calcined before use.

In practice, it is not always feasible to build the whole of the interior of a furnace of basic material; as a rule only the hearth portion is so formed. Roof and ports which have only heat to resist—not the action of the slag—are built of acid bricks. In considering the action of a basic slag on an acid lining, it is equally obvious that similar conditions hold good when acid and basic refractory materials are heated in contact. This remark introduces the second class of refractory materials—termed neutral in that they are unaffected by either basic or acid materials. Evidently, then, a neutral material can act as an isolating layer between the acid and basic portions of a furnace. Such a material is found in chromite, an extremely refractory substance. The composition varies between the following limits :—Chromic oxide, from 40 to 60; magnesia, from 6 to 18; ferrous oxide, from 15 to 36; alumina, from 5 to 30. Were it not for the difficulty of fritting together chromite would make an excellent hearth. As it is, its use is confined to that of an isolating layer between acid and basic material. Carbon, an extremely refractory and neutral material, is met with in foundry practice chiefly in the form of facings and as a constituent of plumbago crucibles. These crucibles contain from 25 to 50 per cent. graphite, the remainder being a mixture of fireclays. Plumbago or graphite varies in quality, and may contain from 36 to 96 per cent. carbon. The former content is often met with in adulterated plumbago facings. Normal graphite contains 80 per cent. carbon, whilst best picked Ceylon samples may reach up to 99.8 per cent. carbon—practically pure carbon. The most interesting members of the neutral group of refractories are found in fireclays. These clays are essentially hydrated silicates of alumina, and when pure correspond to the formula : Al_2O_3, $_2SiC_2$, $_3H_2O$. In other words, a pure clay, before burning, should contain :—Silica, 46.5 per cent.; alumina, 39.5 per cent.; combined water, 14.0 per cent. A clay of

this composition would begin to soften or fuse in the neighbourhood of 1,830 degrees C. The nearest approach to purity is found in china clay—generally compositions vary between the following limits :—Silica, 50 to 65; alumina, 25 to 35; combined water, 10 to 14. Four actual analyses are as follows :—

Fireclays.

		China.	Stourbridge.	Derby.	Stannington.
Impurities.	Silica ...	46.3	63.3	52.0	47.6
	Alumina	40.0	23 3	36.0	35 4
	Magnesia	0.4	Trace	0 5	1.1
	Lime ...	0.4	0.7	0.8	1.0
	Ferric oxide...	0.27	1.8	2.0	3.5
	Combined water	12.67	10.3	9.0	10.6

The impurities of a clay are—magnesia, lime, oxide of iron, and alkalies. The special properties of a clay do not depend on the presence of any one impurity. Further, the exact influence of the impurities in relation to each other is not accurately known. In any case the alkalies—soda and potash—should together not exceed a total of 1 per cent. The best means of testing a clay is a practical one; that is, moulding cubesof the clay and heating them to a temperature just a little higher than that which the clay will have to meet in practice. The appearance of the corners will give a fair index of the heat-resisting properties of the clay. In the foregoing analyses the term combined water will have been noted. Contradictory though it may seem, this represents the amount of water in a dry sample—in other words, chemically combined water. Heated to a low temperature, the hygroscopic water is driven off; when heated to a high temperature, the combined water is expelled and the clay becomes "burnt." It is, therefore, on the presence of combined water that the plasticity of a clay depends. No amount of added water will restore plasticity to a burnt clay. In the form of bricks, fireclays are used for the internal construction of air furnaces, crucible furnaces for brass melting, and cupola linings. These bricks are also used to form the hearth portion of an air furnace for melting brass. Similar furnaces for cast iron sometimes have the hearth formed of sand rammed on the top of the fire brick. Fireclays are also used for the manufacture of clay crucibles for steel melting. Both for bricks and crucibles a mixture of clays gives a better result than an individual clay.

So far, the materials considered are, in a sense, natural products. Their preliminary treatment includes weathering in the case of clays, calcination in the case of basic materials, and in all cases reducing to a more or less fine state of division before admixture and manufacture into brick or crucible. Dissimilar mixtures or artificial products are not extensively used. However, one of these may be noted. This is sold under the name of puramachos, and consists of powdered quartz mixed with 10 per cent. of clay. The clay is added in order to give a bond to the quartz, which may be further increased by wetting with a solution of silicate of soda. In some respects this product may be likened to an artificial Gannister high in alumina. Its analysis is approximately :—

Alumina	14.0
Silica	80.2
Soda	3.2
Combined water	2.6

Turning from furnace materials to moulding sands, certain points of similarity are noted in that both must resist high temperatures; further, moulding sands being acid, it follows that silica is a predominant constituent. But whilst there are points of similarity, there are also many points of dissimilarity, and I believe, gentlemen, you will agree with me in stating that the requirements of a sand are, on the whole, greater than those of furnace linings. Broadly speaking, the latter have to resist heat, furnace atmospheres, the action of liquid slags and metals. To some extent the behaviour of a lining in relation to the foregoing requirements can be foretold from its analysis. This naturally gives birth to the question, "Can we foretell the behaviour of a sand from its analysis?" Whilst raising the question the author will delay an answer for a few moments, in order to examine some of the essentials of a moulding sand. As we are taking sands alone, it is necessary to exclude facings, coal dust, horse dung, etc. A moulding sand should, with the minimum of trouble, produce a clean casting. This naturally involves that the metal poured into the mould shall not fuse or soften the sand. We have already seen that mould temperatures vary with the character of the metal or alloy poured into them. Therefore, moulding sands being acid materials, it should follow that the higher the content of silica the greater the heat-resisting properties. Examination of many types

of sand shows that the silica does vary somewhat as follows—though this cannot be taken as a hard and fast rule :—

Type of casting.	Brass.	Light cast iron.	Medium cast iron.	Heavy cast iron.	Steel
Content of silica ..	78 to 80	80 to 82	82 to 81	84 to 88	90 to 95

If, therefore, resistance to heat was the only thing desired, the foregoing classification would offer an excellent means of grading moulding sand.

A consideration quite apart from temperature is, however, found in the *searching* action of liquid metals. It can be taken as an axiom that the greater the fluidity the greater the penetration into the mould. For example, we may take a series of moulds—say, ½ cwt. cubes—prepared from one batch of sand, all equally rammed, and all in the same condition as regards moisture, but none of them faced. We will assume that the sand is in a moderately fine state of division, such as would be usual for a cast-iron mould, and that it contains 84 per cent. silica. Into one mould fluid cast iron is poured at a temperature of 1,350 degrees C. A certain amount of sand will stick to the cold casting, but it will permit of removal by a wire brush. Into another mould mild steel, at a temperature of 1,600 degrees C., is poured, and from the cold casting adhering sand will not permit of removal by a wire brush. It will, in fact, have fused into a silicate of a more or less glassy nature, and will require chipping off. This is purely a temperature effect, but turning to the other extreme, and taking an example from lead, it will be found that a casting poured at 400 degrees C. will come out with a perfectly smooth skin. If another casting is poured at 675 degrees the sand will adhere most tenaciously and the casting be full of veins. The adhering sand will give every appearance of being burnt—if not actually fused—yet the temperature is only half that of cast iron, which at 1,350 degrees would yield a smooth casting. Although not actually a fusion of the sand into a silicate, the difficulty in dressing the casting is as great. Probably the most common example of "searching" is found in phosphor bronze, which at a normal temperature is extremely fluid, and will penetrate into the pores of a mould, binding the individual grains of sand into a dense and compact mass—a fact very familiar to brass founders, and one readily appreciated by the dressers.

Therefore, in certain cases, a moulding sand must resist, not only temperature, but also the penetrating action of a thinly fluid metal or alloy. Of necessity, this latter property must be associated with porosity in the sand. Could an impervious mould be used there would be no difficulty in arresting penetration. However, the substance of the mould must be of such a nature as to offer a free escape for the gases generated on casting. Further, the sand, when rammed into shape, should be firm to resist liquid pressure, and strong to resist the washing action of a stream of molten metal. These do not constitute all the desirable features of a sand; incidentally it should give a clean, smooth skin to the casting and be readily removed from it.

Reverting to the chemical composition of sands, they are found to contain—in addition to silica—varying amounts of alumina, magnesia, lime, and metallic oxides. Alumina increases the cohesion of a sand—that is, its binding qualities—but at the same time it destroys porosity. Lime and metallic oxides, if in excess, increase the fusibility—hence, destroy heat-resisting properties. Soda and potash are equally harmful in this respect, but they are not usually present in dangerous quantities.

The fact that alumina increases the binding properties of a sand permits of another form of classification—thus:—

Type of Casting.	Light bra.-s.	Heavy brass & light iron.	Medium iron.	Heavy iron.
Content of Alumina	12	10	8	6

To put this table in another light—clay water is often added to a sand lacking "grip." This addition of clay adds alumina to the sand, thereby increasing its binding properties. Where, however, sand is used green, alumina must not be higher than the amounts specified, owing to its tendency to bake like brick and so become impervious.

A thought occurs here in the fact that loam often contains large amounts of clay, and, therefore, comparatively large amounts of alumina. But it must also be remembered that loam mixtures containing clay in excess also contain a certain amount of sharp sand. The distribution of these angular grains of sand through the mixture keeps it open in character, and on drying effectually prevents baking, in the sense of a compact non-porous mass.

Turning to some actual analyses of moulding sands, the following will be of interest:—

Analyses of Sands.

	Black.	Mansfield.	Kidderminster.	S. Staffs.	Glasgow Building Chips.	Clyde Rock.
Silica ...	78.5	83.40	83.69	85.52	92.75	87.32
Ferric oxide ...	6.0	3.14	4.10	3.72	2.50	3.74
Alumina	4.75	7.47	6.26	5.47	2.56	7.10
Lime ...	0.3	0.20	0.66	0.74	0.27	0.64
Magnesia	—	0.62	0.51	0.52	trace	0.31

In justice, I ought to add that the Mansfield sand represents an analysis made in 1896. The black sand is taken from the floor of a foundry making light castings, and was also made in 1896. The other analyses are comparatively recent, and I am indebted to the courtesy of our Secretary and President for samples of Kidderminster and South Staffordshire.

The sample of rock sand was kindly forwarded by Messrs. D. Rennie & Company, Camlachie Steel Foundry, and was, I believe, obtained from the sand quarries of Messrs. J. Baird & Sons, Glenboig.

Examination of Mansfield, Kidderminster, and South Staffordshire will show that there are no startling chemical differences, and geologically the three are identical. Yet in practice they behave very differently. Thus, Kidderminster is more given to "scabbing" than South Staffordshire. A further interesting feature given by our President is that moulds faced with the latter do not require dusting with plumbago or blacking. Mixed only with coal dust, South Staffordshire sand will produce castings of clear smooth skin, without the aid of any facing. Such is not the case with Mansfield sand, and here a charcoal or plumbago facing is essential to a smooth skin. In this respect Belfast sand, as used in this district, is very similar to Mansfield.

These differences in behaviour cannot be accounted for by chemical analysis, for the three are practically identical. State of division—that is, fineness of the particles will not account for it—for the three sands in the same state of fineness will be found to behave differently under practical conditions. Angularity of particles may have some influence, but this is a subject beyond our immediate purpose.

The foregoing sands enter into green or dry sand, and loam mixtures. Rock sand is extensively used for dry sand work, and for this purpose a better facing sand will be hard to find.

Steel castings—when of light section—are made in green moulds, as in the case of cast iron, the difference lying in a facing of powdered silica (silica flour) being used instead of charcoal or plumbago. The majority of steel moulds are, however, made in dry sand, and the sand used is unlike that of the iron or brass founder, not a natural product. With steel, resistance to high temperature is a very necessary quality; this is met by the use of mixtures sold under the term of steel moulding composition. These compositions vary in silica from 50 to 60 per cent., and in alumina from 20 to 40 per cent.

In reference to what has already been said as to alumina, its high content in a steel moulding composition is noteworthy. A distinctive feature must be noted here, viz., sands are used in a natural state—*i.e.*, as quarried—whilst steel moulding compositions are mixtures of "burnt" material. That is, mixtures of burnt firebrick, old clay crucibles, etc. Sand and clay, on burning, lose their plasticity, thus parting sand, when wet, will not cohere, and burnt bricks, after grinding, cannot be again used for brick-making.

The burnt alumina present in a composition does not, therefore, impart plasticity; it simply increases the resistance to heat. Obviously, a mixture of ground brick and crucible will not cohere on damping, and some substance must be added to give "bond." Suitable binding agents are found in glucose, or varieties of core gums. On analysis this bond is reported as organic matter, of which there is usually 5 per cent. present. Carbon, in the form of ground coke dust, is also added to the extent of 3 per cent.

Usually, compositions are purchased ready for use. Where home mixing is attempted, silica sand, "bonded" by the addition of clay water, forms the basis of the mixture. The following mixtures, given recently in "Stahl und Eisen," give an idea as to the ingredients employed:—

	Light steel		Heavy castings.	
	A.	B.	C.	D.
Old facing sand	4	12	1	—
Old crucibles	1	—	10	—
Old fire brick	1	—	5	—
White clay	1	1	3	2
Coke dust	½	—	1	—
Silica sand	—	5	—	10
Graphite	—	2	—	—

Here it will be noted that clay forms the "bond."

CAST IRON.

By Herbert Pilkington, M.Inst.C.E., M.I.Mech.E. (Vice-President).

The selection of pig-iron, its mixing and melting, and subsequent treatment in the foundry, must always be a subject of profound interest to every foundryman, and yet it is doubtful if in this country this branch of foundry practice has received that consideration and attention which its importance demands. It is true that during the last few years there has been such an awakening of foundrymen to the scientific considerations which bear upon foundry practice generally that this reproach is within measurable distance of being removed, and the formation of the "British Foundrymen's Association" is concrete evidence of that fact. The writer does not desire to be misunderstood upon this point. There are many foundries where every care and consideration is given to this subject, where chemical analysis and mechanical tests control or advise the whole working. On the other hand, there are many more where it receives little or no attention; there are others who keep chemists or receive analyses, and yet possess no one in authority who is capable of interpreting or adequately using such advice. There are many very practical and successful foundry managers who dread to lose a certain brand of pig-iron out of their mixtures because the brand that replaces it appears to them to lead them into the unknown—and it frequently does. There are others who rely upon the wisdom of the cupola minder. In these days, however, the thirst for accurate knowledge is too great for this kind of practice to continue, and we are constrained to gather from scientific men all the information we can possibly get, and to call in and use the chemist in every possible way we can. It is, however, not alone the practical man who has hitherto neglected scientific research in the foundry, but also the metallurgist, whose attention has mostly been bestowed upon steel and its manufacture. There are, however, without doubt, numerous signs that this apparent neglect is becoming a thing of the past, and that we are entering upon a period of enlightened enquiry in the foundry in which the Association will doubtless take an honourable and important part.

Cast iron, the metal with which foundrymen have principally to deal, is a metal of exceedingly varied composition and complex physical construction. Pig-iron in its crudest form varies principally with the district in which it is produced, and, generally speaking, has a defined character in accordance with the character of ores obtainable in that district. Thus, we have Scotch, Cleveland, Frodingham, Derbyshire, Northamptonshire, North Staffordshire, and South Staffordshire pig-iron, and other pig-irons such as hematite, cold blast, basic, cinder iron, and certain special irons, which are made indifferently in any districts where the material to make them is available. As we are dealing with such irons only as are available for foundry purposes, only those will be considered. The table of analyses here given shows the typical chemical composition of each of these general types of pig-iron and the principal ores used to make them. Pig-iron rarely contains more than 93 per cent. or 94 per cent. of pure iron, the other constituents consisting of silicon, sulphur, phosphorus, manganese, and carbon. There may possibly be present minute quantities of other elements, such as titanium, copper, etc., but these are rarely present to an appreciable extent

No. 3 Foundry.

—	North Staffs.	South Staffs.	South Staffs.	—
	—	All mine.	Cold blast. No. 5.	Hematite. West Coast.
Graphite carbon	2.53	2.56	2.15	3.25
Combined „	0.42	0.37	0.61	0.51
Silicon	2.89	2.35	0.95	2.10
Sulphur	0.029	0.06	0.11	0.04
Manganese ...	1.92	0.73	0.72	trace
Phosphorus ...	1.29	0.62	0.51	0.045
Ores used :—	Calcined Blackband. Clayband. Oolitic		Calcined Clayband.	Hematite.

—	Scotch.	Cleveland.	Frodingham.	Derbyshire.	Northampton.
Graphite carbon ...	3.35	3.16	3.10	3.65	3.10
Combined „ ...	0.20	0.48	0.56	0.31	0.35
Silicon	2.15	2.59	2.75	2.60	3.20
Sulphur	0.055	0.08	0.038	0.02	0.04
Manganese	1.311	0.60	1.68	1.02	0.48
Phosphorus	0.907	1.57	1.32	1.40	1.65
Ores used...	Blackband. Clayband.	Cleveland. Lias.	Lias.	Lias. Oolitic.	Oolitic.

in ordinary English irons. These metalloids and metals materially affect the character of cast iron, and it is due to their relative percentages that one pig-iron has different characteristics than another. It is, therefore, of the highest importance that in all foundries these constituents should be ascertained by analysis, and carefully studied with regard to the ultimate use of the iron in the various classes and forms of castings made. In addition to the chemical analysis of the constituents of cast iron, no paper on that subject in these days can be considered complete without some consideration of the microscopical analysis which of late years has practically given birth to what may be called the new science of metallography. This microscopical research provides the means which enables us to investigate the all-powerful influence of heat on the crystallisation of cast iron and other metals, and the great part which carbon takes in such crystallisation. Cast iron, with its large percentage of metalloids, has been, to some extent, neglected as a subject for research by the microscopists as well as by the metallurgists. Nevertheless, it may be safely assumed that any research work of this character upon cast iron will yield results of equal interest, and possibly of equal importance, to those which have been discovered in steel and other metals. It has been shown that what at one time was thought to be two forms only of carbon in iron and steel, now stands revealed in several modifications, and to these various modifications and their different forms of crystallisation the differing physical characteristics of the metal are in a large degree to be ascribed.

The influence of the constituents of cast iron on the resulting metal are very considerable, both with regard to its strength, fluidity, hardness, and softness, and also its wastage in re-melting and the consumption of coke in the cupola. In this country it is customary for most foundry purposes to use irons containing much more manganese, phosphorus, and silicon than is the case in America. The difference is considerable, and the larger percentages in English irons account for their general superiority as foundry irons. They have, generally, greater fluidity and also greater soundness. Probably two of the best foundry irons in this country to-day are Scotch and Derbyshire, which have a manganese content of 1 per cent. or over. Now, while manganese, *per se.*, is undoubtedly a general weakener and hardener of cast iron, it must be remembered that in re-melting a great deal of it is lost, probably about a third, and its loss means a loss of sulphur also. Very strong irons, indeed, may contain as much as 75 per cent. of manganese. Manganese also increases the power of iron to retain carbon. A foundry pig containing 1 per cent. of manganese will, as a general rule, be very low in sulphur, and will not be excessive in silicon, because the conditions at the blast furnaces are favourable. In re-melting, the iron always picks up sulphur from the coke used, and if the manganese is carried forward into the ladle it mostly eliminates the sulphur while waiting to cast. The cupola itself is a bad mixer, but large foundry ladles or receivers are good ones, and should be used wherever possible to facilitate the reactions. The hotter melting and increased fluidity derived from the use of silicon, manganese, phosphorus in English irons is very desirable for very many classes of foundry work. Most cupolas in this country waste their manganese in melting, through the acidity of their slags, and it would be better in every way if cupola slags were rendered more basic by the use of more limestone as flux for the coke-ash and other impurities. In re-melting, there is, of course, a loss in all the impurities of pig-iron except the sulphur and combined carbon, which always increase. This is illustrated by the following analyses from experiments conducted by Jungst in the Imperial Foundry at Gleiwitz :—

	1st Melting.		2nd Melting.		3rd Melting.
Carbon (Graph.) ...	2.73	...	2.54	...	2.08
„ (Combd.)...	.66	...	.80	...	1.28
Silicon	2 42	...	1 88	...	1.16
Sulphur	.04	...	.10	...	.20
Phosphorus ...	.31	...	.30	...	.28
Manganese... ...	1.09	...	.44	...	.36

These results illustrate the loss of manganese, graphite, and silicon, and the increase of combined carbon and sulphur. Manganese has often been used in chilling work, such as chilled rolls, where it is entirely out of place, and can only tend to weaken the chill if used in amounts over 1 per cent. This quantity does not appear to affect the carbon; the best practice is under .7 per cent. On the other hand, in chilling irons, sulphur may be present, as in No. 5 Staffordshire cold-blast iron, to the extent of .15 per cent., without any ill effects, and, without doubt, assists as a hardener. In the presence of very low silicons, such as are used in chilled roll making (*i.e.*, .8 per cent. to 1 per cent.), this amount of sulphur

doubtless has some effect upon the carbon. It is worthy of note that in this class of chilling iron, phosphorus is usually about .5 per cent., and that the iron is of great transverse and tensile strength, and it is also very hard to machine, but, when machined, is usually exceedingly sound and clear. American chilling irons invariably contain much lower sulphur and phosphorus than English.

In this country, for chilled roll making, the iron is always melted in an air furnace, at all events where the best practice obtains, because of the higher temperature and more efficient mixing, and also the absence of contamination.

Sulphur causes carbon to assume the combined form, and, therefore, should be avoided in all soft castings, or those required for easy machining. It also tends to the formation of dirt spots in castings. Most of the sulphur in grey castings is derived from the coke used in melting, and it is of the highest importance that only such cokes should be used as are low in sulphur. No coke should be used containing over 1 per cent. sulphur, and that is too high for really soft work.

Sufficient lime should be used in the cupola and sufficient manganese in the mixture, and, above all, hot melting should be the general practice. The use of receivers, or large cupola ladles, is much to be advocated to act as mixers where the metal can cool to the required casting temperature. Where two or three brands of iron are mixed this is especially important, as it is by no means easy to get varying irons to readily mix otherwise. These conditions are all favourable to the production of clean, sound iron.

Phosphorus is present in cast iron in the form of phosphide, and appears to have little influence on the carbon. It promotes the fluidity to a large degree, and ornamental and light artistic castings may, and often do, contain up to 2 per cent., and in extreme cases as much as 3 per cent. On the other hand, all phosphoric iron is brittle and hard, and it should, therefore, be used with judgment. Irons with very low phosphorus contents make castings, other things being equal, much too soft for many purposes, and hematite irons may generally be classed in this category.

Silicon much promotes fluidity, and is a very important element in cast iron, and, in many senses is the foundry controller in a given iron as to its grading, No. 1 iron being the most silicious and white iron the lowest in silicon content. Professor Turner has shown the results that the various proportions of silicon in cast iron produce :—

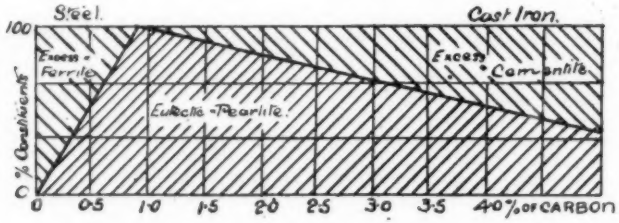
	Per cent.
Maximum hardness under	0.80
Crushing strength about	0.80
Density about	1.00
Combined crushing tensile and transverse strength about ...	1.40
Tensile strength	1.80
Softness and working qualities ...	2.50
Lowest combined carbon	5.00

Owing to the property which silicon has of throwing out of solution the carbon—in the form of graphite—glazed and silicious irons and ferro-silicons have been frequently used as softeners. Considerable care is, however, necessary in order to get a thorough mixture of the metals, as the cupola itself is not an efficient mixer; also, the character of the scrap has to be carefully watched. The more silicious pigs will, of course, carry more scrap and harder scrap than those of lower silicons, but the resulting castings, even soft ones, ought not to greatly exceed 2.5 per cent., as silicon, *per se.*, is undoubtedly a great weakener of iron. The temperature conditions in the blast furnace that produce high silicons in pig-iron are exactly those which favour very low sulphur, as in No. 1 pig-iron, and the temperature conditions which favour high sulphur are those which favour low silicons, as in the case of white iron. The writer, has, however, known many exceptions to this apparent rule in pig-iron, produced by changes in fluxing and mixing, and it is doubtful if any grading of pig-iron by analysis alone will ever be perfectly satisfactory if silicon is the element relied upon, as is frequently suggested. This question of grading by analysis is much discussed in these days, and it is noticeable that casting machines for foundry pig-iron in this country have made no headway, the pigs, where mechanical handling has been introduced, being cast in sand, and lifted by cranes and broken by machines. This is done to preserve the fracture, as the buyers generally will not take the iron from casting machines owing to the broken, chilled, or scattered fracture caused by casting in iron moulds. This may be prejudice, but the writer is of opinion that silicon is an unsafe guide, of itself, to the grading character of foundry pig-iron without the assistance of fracture. High silicon may occasionally be found in forge pig-iron, and high sulphur may be found associated with it at times. The fact is, that the fracture shows that the carbon is either in a normal or an abnormal condition, and that is of value in itself.

If a very grey iron at the blast furnace is run into pigs in sand very slowly, its fracture, when cold, is a very wild and scattered one, and it would in all probability be graded as No. 4 foundry, but by analysis it would be graded as No. 1 and 2 iron. If the usual amount of scrap that No. 1 or 2 carries were melted with this iron in the cupola, the resulting castings would be very much harder than usual; in fact, in many classes of work it would give trouble. This iron, in cooling on the pig-beds, always throws out abnormal quantities of kish. It has been said that whatever may be wrong with the pig-iron in its carbon, that when remelted, that carbon is all restored to a normal condition in the casting. It does not appear possible to controvert such a statement, but the class of iron just referred to is *not* restored to a normal condition, and I am afraid is little known to metallurgists. Whether it leaves anything behind it in the kish on the pig-beds, or whether the melting temperature of the ordinary cupola is insufficient to restore it to normal condition, the writer does not pretend to say, but the facts are as given. In all probability, a little microscopical research on this iron, which is frequently produced, would reveal something of considerable interest; meanwhile, pig-iron for foundry purposes will doubtless continue to be bought by both fracture and analysis combined, as is now being done, and as has been dictated by experience, or until we all get a little better educated in its mysteries.

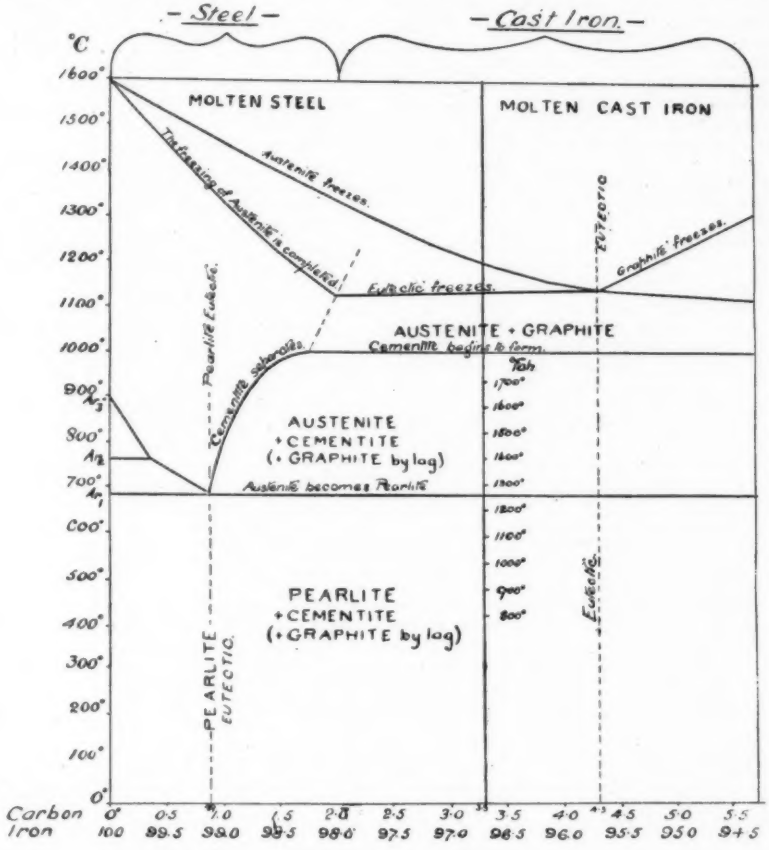
Carbon in cast iron may range from 2 per cent. to over 4 per cent. in white iron. In white iron this carbon is nearly all in combination, and in No. 1 iron it nearly all exists as graphite, the former being the hardest end of the scale and the latter the softest. Combined carbon, therefore, is a hardener of cast iron; in fact, it is the greatest hardener. Shrinkage in cast iron is increased according to its hardness generally, and, therefore, is principally controlled by the combined carbon. Silicon tends to exclude carbon and throw it out as graphite, whilst sulphur has the opposite effect. In the molten state all the carbon is in solution, but in cooling down, when silicon is present in sufficient quantity, most of the carbon separates from solution, forming graphite, which is familiar to all as the bright scales uniformly distributed throughout the metal, and which confer upon it its softness. The carbon which separates out after solidification in the form of a fine powder is usually called temper carbon, or temper graphite.

Of late years the forms of combined carbon in iron have been very extensively enquired into by means of the microscope used upon the etched surfaces of the metal. The microscopical analysis of cast iron itself has not been investigated to anything like the extent that steel has been examined, and in many ways, so far as published records go, we have to base our deductions with regard to cast iron upon the investigations made upon steel. These show that the iron-carbon alloys contain two defined crystalline constituents, *i.e.*, ferrite, or pure iron, and cementite, or iron carbide, Fe_3C., also pearlite, the eutectic mixture of cementite and ferrite. This latter contains 13 per cent. of cementite and 87 per cent. of ferrite. Cementite contains 6.9 per cent. carbon, while pearlite contains 0.89 per cent. The diagram given above, after Sauveur, illustrates these three constituents as they exist in steel or white iron according to its content of carbon, which is shown on the horizontal scale. Thus, iron with .89 per cent. of carbon in combination is constituted wholly of pearlite, while a white cast iron of 3.5 per cent. of carbon would be constituted of 62 per cent. of pearlite and 38 per



CONSTITUTION OF IRON CARBON COMPOUND (SAUVEUR).

cent. of cementite. These constituents segregate and form the solid mass in cooling down. This solid segregation is a phenomenon of profound interest and importance. The diagram below, after Roozeboom, shows in graphic form the various results as they occur in the cooling down of iron-carbon alloys. The vertical scale is temperature, and the horizontal scale carbon contents. If we take as a concrete example an iron containing 3.3 per cent. of carbon, and trace it on a diagram where it is marked by a vertical red line, we can observe what changes occur in cooling down from a molten condition to the cold solid state. The upper curve, which is an ordinary freezing curve, having the shape of a flattened V, with a horizontal line underscoring it, represents the temperature and composition at any moment. The underscoring line shows the temperature at which the final solidification occurs, that is, the freezing point of the eutectic or mother liquor. The upper V curve shows the temperature at which partial freezing commences; thus it will be seen that the upper curve cuts the red ordinate, corresponding to 3.3 per cent. carbon, at a point indicating 1,200 degrees C., or 2,192 degrees F. At this temperature partial solidification occurs, owing to the iron containing more saturated austenite than is required to form the eutectic composition.



B8EA ROOZEBOOM'S DIAGRAM.

Austenite is a solid solution of carbon

in iron, and may vary in composition. The term austenite is used in its widest form for the sake of simplicity, and includes such constituents as hardenite, martensite, troostite, and sorbite, which three latter are transition forms between austenite on the one hand and ferrite and cementite on the other. From 2,192 degrees F. down to 2,050 degrees F. austenite separates out, and then at this temperature the mother liquor has attained the eutectic composition and solidifies. The mixture of austenite and graphite, of which the eutectic is formed, contains 4.3 per cent. of carbon. It will be seen that the upper curve dips down and touches the underscoring line at this composition, and that with iron containing more than 4.3 per cent. carbon the upper line again ascends; the excess solidifying this time, however, is graphite. Final solidification, then, occurs in an iron of 3.3 per cent. carbon at about 2,050 degrees F., and the iron then consists of austenite and graphite. In cooling downwards, the next point of change occurs at 1,830 degrees F., when the austenite begins to break up into cementite, and normally cooled metal between this temperature and the lower line at 1,260 degrees F. would be found to consist of austenite (or its modifications), cementite, Fe_3C, and graphite. The percentage of graphite would, however, be less in this region, as to form cementite containing 6.9 per cent. of carbon, some of the graphite is absorbed into the iron, and in the case of white iron practically all the graphite so disappears. On passing the 1,260 degrees F. line the austenite (which would be found to have attained a composition of 0.9 per cent. carbon approximately, and is then often termed hardenite) is converted to ferrite, or pure iron and cementite, Fe_3C. These constituents interstratify in layers, and so produce a constituent which, from its appearance under the microscope after etching, has been called pearlite, so that in a normally cooled iron, or iron and carbon alloy of 3.3 per cent. of carbon, we should expect to find a metallic structure consisting of pearlite and cementite, and in addition through lag of the absorbing reaction, graphite.

If the iron contains silicon and other metalloids, as in the case of grey cast iron, these results are, of course, modified thereby; thus we know that silicon promotes the separation of carbon as graphite and thereby reduces the amount of cementite formed. In very grey pig-iron with high silicon content, nearly the whole of the carbon, with the exception, perhaps, of .10 per cent., may be graphite, and, therefore, not in solution.

Rapid cooling from above any of these points of critical temperatures indicated by the horizontal lines cannot but have some effect on the physical properties of the iron. We should also expect to find at the temperature corresponding to these critical points an alteration in the rate of cooling. Professor Turner caused the cooling curve of No. 1 Northampton iron to be taken by Mr. O. F. Hudson, and three distinct points of retardation occurred at temperatures of about 1,115 degrees C., 935 degrees C., and 860 degrees C.

The lower line on the diagram—1,260 degrees F.—is an important one, as it is at this point where pearlite is formed, and also where the constituent known as sorbite is produced. Sorbite is a variety of pearlite, but of a more homogeneous structure, and which is now known to give much increased strength to steel treated at or about this temperature.

A paper read at the Barrow meeting of the Iron and Steel Institute by Messrs. Stead and Richards on sorbitic steel rails, brought forcibly to the writer's mind certain facts observed with regard to cast iron, and caused him to make a few experiments. A number of bars were, at a cherry-red heat, dipped for a little over a minute in a convenient blacking bosh, and then lifted out and left to cool naturally, the results of which are shown in Table No. 1. Another series were tried, as shown in Table 2, with the addition of a test in clean, cold water. Finally, two other series of bars were tried on the more elaborate scale in which analyses and temperatures were taken, and the results were recorded in Tables No. 3 and 4. It must be noted that in these tables the cooling is only of a negative character, owing to the bath being practically a thin mud bath, and also owing to the time of immersion. The most effective temperature for maximum strength was undoubtedly at or about 1,300 degrees F. Quenching at the lower or higher temperatures much diminished the strength. Absolute quenching appears to have this effect also. The writer does not pretend to do anything more than record the facts of these perhaps somewhat crude experiments, but although they lack completeness, they appear to be sufficiently important to suggest that there may be sorbitic castings as well as sorbitic rails.

In all these experiments, many of which

TABLE 3.—*Heat Treatment of Test Bars.*

No. of Test.	Character of heat treatment.				Analysis after treatment.						Mechanical test.				
	Temperature when dipped.	Temperature when taken out of bath.	Time occupied in dipping.	Remarks.	Graphite carbon.	Combined carbon.	Silicon.	Phosphorus.	Manganese	Sulphur.	Transverse tests. Size 36 in. by 1 in. by 2 in. deep. Strength.			Defl.	Tensile tests. Size 1¼ in. Strength.
											Cwts.	qrs.	lbs.	ins.	Tons per sq. in.
1 ...	Untreated, cooled in box				2.85	0.58	2.175	1.337	0.085	0.058	28	2	12	.347	10.34
	°F	°F													
2 ...	900	500	1½ min.		3.00	0.45	1.960	1.441	0.790	0.050	25	3	0	.320	9.41
3 ...	1,000	505	,,		2.88	0.52	1.960	—	—	—	22	0	9	.305	9.66
4 ...	1,100	500	,,		2.88	0.49	2.025	—	—	—	32	0	20	.438	10.32
5 ...	1,200	510	,,		2.87	0.48	2.025	1.441	0.810	0.052	31	3	18	.393	9.89
6 ...	1,300	505	,,		2.94	0.50	2.025	—	—	—	31	1	24	.400	9.94
7 ...	1,400	505	,,		2.94	0.51	2.025	—	—	—	35	3	20	.455	10.28
8 ...	1,520	510	,,		2.90	0.60	2.025	—	—	—	under	16	cwts.	.240	9.38
9 ...	1,600	510	,,		2.84	0.68	2.025	—	—	—	,,	12	,,	.122	5.45
10 ...	1,700	510	,,		2.87	0.68	1.960	1.367	0.770	0.051	,,	12	,,	.190	broke

TABLE 4.—*Heat Treatment of Test Bars.*

No. of Test.	Analysis of bars as cast.						Analysis of bars after treatment.						Character of heat treatment.							Mechanical tests.				
	Graphite carbon.	Combined carbon.	Silicon.	Phosphorus.	Manganese.	Sulphur.	Graphite carbon.	Combined carbon.	Silicon.	Phosphorus.	Manganese.	Sulphur.	Casting temperature.	Temperature when stripped.	Quenching temperature.	Temperature after quenching.	Temp. of bath. Before.	Temp. of bath. After.		Transverse. Size, 36 in. × 1 in. × 2 in. Strength.			Defl.	Tensile.
													°F.	°F.	°F.	°F.			Min.	cwts.	qrs.	lbs.	In.	
April 4th—1	2.70	0.65	2.313	1.15	0.65	0.060	2.83	0.50	2.333	1.118	0.62	0.062	2180	1275	1133	505	62	205	1¼	28	3	4	.380	
April 4th—2	2.68	0.74	2.313	1.29	0.835	0.060	2.70	0.68	2.331	1.283	0.82	0.058	2180	Couple broke.			98	203	1½	30	3	20	.412	
April 5th—3	2.60	0.71	2.505	1.37	0.975	0.045	2.87	0.48	2.231	1.363	0.95	0.041	2200	1100	1150	500	53	200	1½	32	3	26	.392	

TABLE 5.—*Results of Heat Treatment of 12 in. by ½ in. sq. Test Bars obtained by Mr P. Munnoch.*

Chemical analysis of bars.									Mechanical tests of bars.											
As cast.						Reheated.			Transverse strength and deflection.								Shrinkage.			
									As cast.		Annealed.		Air cooled.		Quenched.					
Graphite.	Combined carbon	Silicon.	Manganese	Phosphorus	Sulphur.	Annealed. Combined carbon	Air cooled. Combined carbon.	Water qu'ncd. Combined carbon.	Strgth.	Deflect.	Strgth.	Deflect.	Strgth.	Deflect	Strgth.	Deflect	As cast.	Annealed.	Air cooled.	Qnchd.
									410	.19	450	.25								
									335	.19	400	.23	4 0	.24	440	.25	.152	.101	.102	.102
									375	.18										
									400	.23	400	.27								
2.99	.73	2.24	1.15	1.07	.060	,,	,,	Trace.	390	.23	390	.27	420	.32	480	.36	.158	.100	—	.103
									390	.24										
									420	.24	420	.23								
2.95	.75	2.45	1 05	1.03	.057	,,	,,	.24	395	.18	395	.21	395	.20	530	.26	.153	.092	—	.095
									355	.18										
									500	.29	400	.30								
3.22	.53	1.96	.56	.59	.060	,,	,,	,,	485	.29	400	.29	405	.31	480	.39	.155	.090	—	.094
									470	.26										
									410	.25	370	.23								
—	.53	2.54	.55	.69	.078	,,	—	—	435	.24	370	.21	450	.34	435	.32	.150	.099		
									375	.19										
									450	.27	395	.30								
—	.43	2 03	.59	.65	.076	,,	—	—	450	.25	385	.28	500	.44	505	.39	.153	.095	.095	.095
									400	.23										
									455	.26	395	.24								
									430	.25	3:0	.22	—	—	550	.38	.152	.105	—	.104
2.9	.40	2.58	.43	.75	.043	,,	—	—	410	.24	360	.21								
									470	.24	440	.31								
									440	.22	400	.24	—	—	225	.10	.155	.118	—	.095
2.92	.43	2.06	.67	.91	.041	,,	—	—	415	.21	280	.22								
									430	.22	420	.24								
									415	.22	400	.23	—	—	290	.16	.154	.093	—	.077
2.94	.46	1.93	.73	1.00	.043	,,	—	—	375	.20	390	.22								
									415	.24	390	.23								
									395	.20	355	.24	—	—	190	.09	.150	.090	—	.055
2.98	.51	2 07	.36	85	.050	,,	—	—	320	.17	325	.18								
									435	.20	425	.26								
									430	.20	420	.24	—	—	460	.34	.150	.098		
2.84	.36	2.49	.66	1.03	.036	,,	—	.14	385	.19	415	.22								
								Average	415	.22	396	.24	437	.31	417	.29	.157	.098	.098	.09

are not recorded here, the bars that were analysed after treatment have never shown less than about .4 per cent. combined carbon, and the reduction in combined carbon by treatment has varied, but has rarely exceeded, .35 per cent. The treatment, however, in every case did effect a reduction in the combined carbon, which is a matter of much interest. All the bars, however, were not analysed.

Mr. Keep records some experiments he made by plunging bars in ice-cold water at certain periods after casting, and

TABLE 1.—*Results of Transverse Tests.*

Date.	Test No	Mark on specimen.	Description.	Distance between supports.	Dimensions.		Ultimate central load.	Deflection.	Remarks.
					Width.	Depth.			
				in.	in.	in.			
—	1	—	Untreated	36	1	2	28 2 20	.333	3 Bars.
—	2	—	,,	36	1	2	28 1 10	.316	2 ,,
—	3	—	Treated	36	1	2	38 0 24	.395	3 ,,
—	4	—	,,	36	1	2	39 0 24	.410	4 ,,

shows the following changes in combined carbon :—

No. 1 Test—
1½ minutes after casting. 0.65 Comb. Carbon.
No. 2 Test—
9 ,, ,, ,, 0.45 ,, ,,
No. 3 Test—
14 ,, ,, ,, 0.03 ,, ,,

It is noted that the marked change takes place in the percentage of combined carbon during the period of third expansion. As bearing upon this quenching question, the writer is enabled, by permission of Mr. P. Munnoch, to show a table (No. 5) of experiments on 12 in. by ½ in. bars, annealed, air-cooled, and quenched, in which there is shown an almost complete disappearance of combined carbon, and the results of the mechanical tests there shown are also of much interest.

TABLE 2.—*Results of Transverse Tests.*

—	—	—	Untreated	36	1	2	28 0 0	.351	—
—	—	—	Sludge dipped	36	1	2	31 1 4	.391	—
—	—	—	Water dipped	36	1	2	26 1 0	.302	—

——o——

IT is stated that Messrs. Yarrow have decided not to go to Port-Glasgow.

BRITISH FOUNDRYMEN'S ASSOCIATION.

To the Editor of the FOUNDRY TRADE JOURNAL.

SIR,—I shall be glad if you will allow me to call the attention of members of the British Foundrymen's Association who have received copies of the proceedings of the last Convention, to an omission, made inadvertently, of course. Also if any member of the Association has not received his copy I should be obliged if he will communicate with me. I should also be pleased if Mr. Meadowcroft, of Leeds, would send me his new address.

In illustrating Mr. Campion's paper, "The Micro-Structure of Pig-iron," mention should have been made of the fact that the first eighteen micro-photographs were made by Mr. O. Hudson, A.R.S.M., Demonstrator of Metallurgy, Birmingham University, from specimens of pig-iron, prepared by him under the superintendence of Professor Turner, who is known to all as a most distinguished authority on cast iron. To both of these scientists our thanks are due. The remaining fourteen micro-photographs are from Mr. J. T. Stead's classical paper. "Iron and Phosphorus," to be found in the "Journal of the Iron and Steel Institute," Volume 2, year 1900.

To the gentlemen named we desire to acknowledge our indebtedness. Thanking you in anticipation,

I beg to remain,
Yours very truly,
F. W. FINCH, Hon. Sec.

THE STEEL CASTING INDUSTRY OF SHEFFIELD.—IV.

(*Continued from page* 497.)

THE works from which the products of Messrs. Vickers, Sons & Maxim are sent forth are amongst the largest in the world. Splendidly arranged, engineered, and conducted, their important work is carried on with precision, accuracy, and despatch. With such a huge and responsible undertaking this must be so; otherwise all would be chaos. A glance at the manufactures of this world-famous firm is sufficient to show that complete and effective organisation is an absolute essential. Given briefly they are :—Ships, naval and mercantile; guns, naval, field, and coast defence; engines, marine, electrical, and hydraulic; armour plates, forgings, and castings, railway material, motor cars, etc. In the design and construction of a battleship the Company can provide all the constructive material and armour required, the machinery and every type of gun with its mechanism and mounting complete. The works are more than equal to several of the Government establishments, and stand practically alone in being able to meet the demands of a nation in the supply of the weapons of warfare afloat or on land, with their steel-making, gun-building, and armour plate works at Sheffield; their shipbuilding, engineering, and ordnance establishment at Barrow-in-Furness; and their gun factories for quick-firing, field, and automatic guns at Erith and elsewhere. The business was established in the later

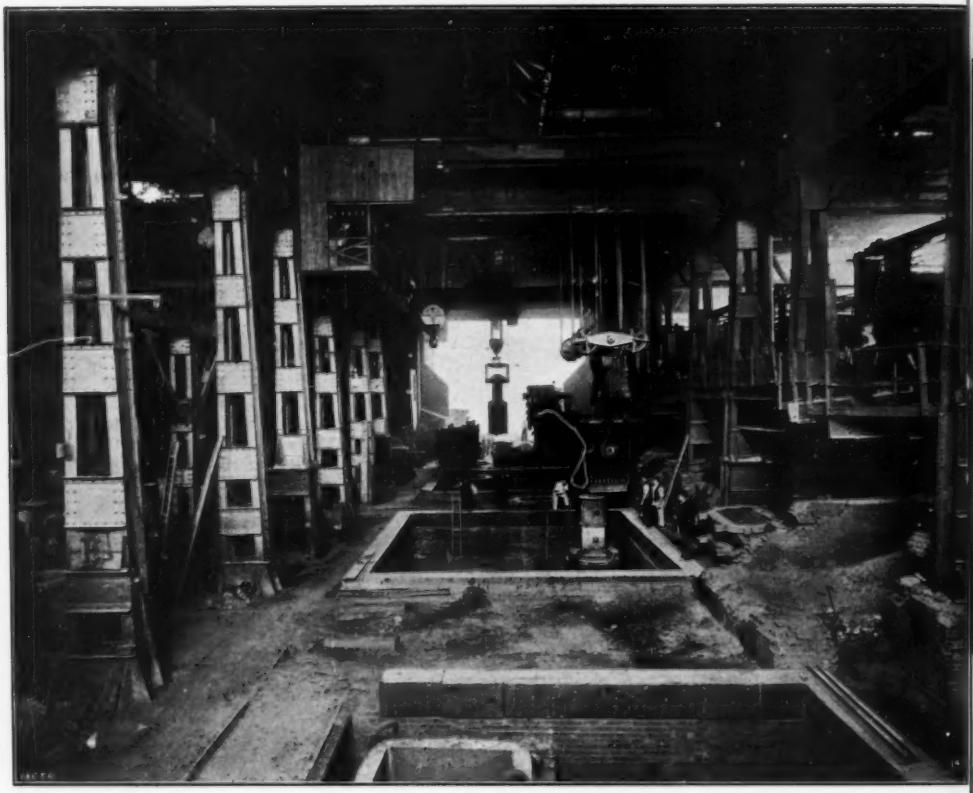


FIG. 1.—MELTING HOUSE CASTING PIT; VICKERS, SONS & MAXIM, LTD.

years of the eighteenth century by Mr. George Naylor—the grandfather of two of the present managing directors, Mr. T. E. Vickers and Mr. Albert Vickers, and the great-grandfather of the managing director, Mr. Douglas Vickers. Mr. Naylor took into partnership, in 1829, his son-in-law, Mr. Edward Vickers. In 1856 Mr. Edward Vickers gave up the control of the business to his eldest son, Mr. T. E. Vickers, who is now the Chairman of the Company, and who was joined later by his brother, Mr. Albert Vickers.

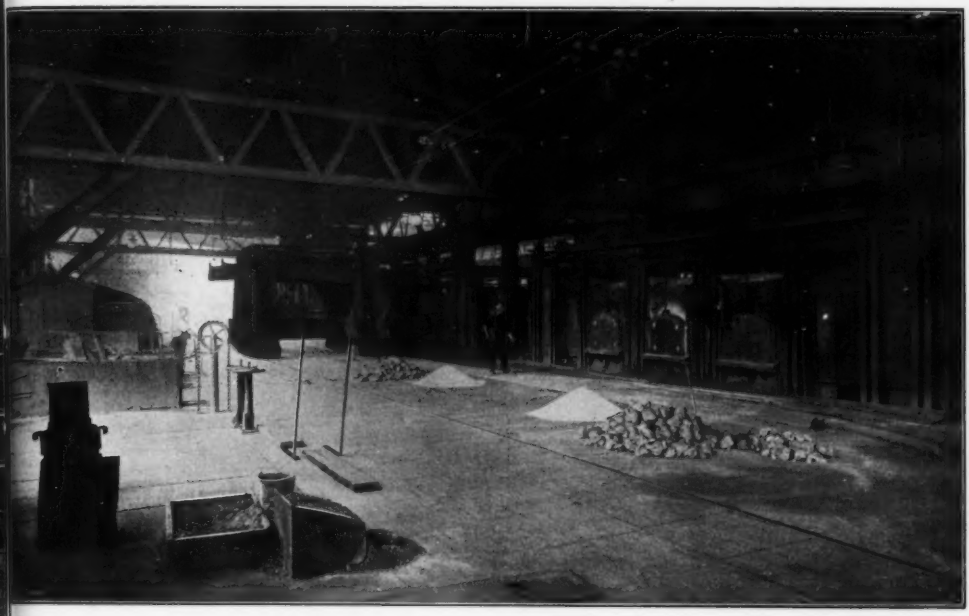


FIG. 2.—STEEL MELTING FURNACES; VICKERS, SONS & MAXIM, LTD.

During its long history the Company have introduced many improvements in the way of machinery; and inventions, irrespective of their source of origin, have been carefully investigated and made suitable for the special requirements of the Company. This has been done although it may have meant discarding plant which seemed quite satisfactory.

The River Don Works were commenced in 1863, the heavy business of the firm having increased to such an extent that the old establishment at Millsands had to be abandoned. Shortly afterwards, the co-partnership was changed into a company, formed under the Limited Liability Act, with a capital of £155,000, which has since risen to over £5,000,000. The area of the Sheffield works has increased from 20 to over 50 acres; the number of workers there from about 1,000 to over 5,000, and while a 15-ton hammer was the largest tool for forge work in the earlier days, there are now in use several hydraulic presses ranging up to 8,000 tons. In 1868 the Company commenced the manufacture of marine shafting, and in 1872 the first screw propeller was cast at the works. In 1882 the first forging press was put down, but the most important development was in the laying down of plant for the construction of guns and armour in the year 1888. The Government, anxious to add to the resources of the nation in the matter of gun construction, made an inspection of several works and offered Messrs. Vickers an order valued at £250,000, with the prospect of more to follow if gun-making plant were laid down. Notwithstanding the immense capital involved, the firm entered upon this important undertaking, and their first gun, tried in 1888, gave every satisfaction. Since then the Company has progressed continually. In 1888, too, the

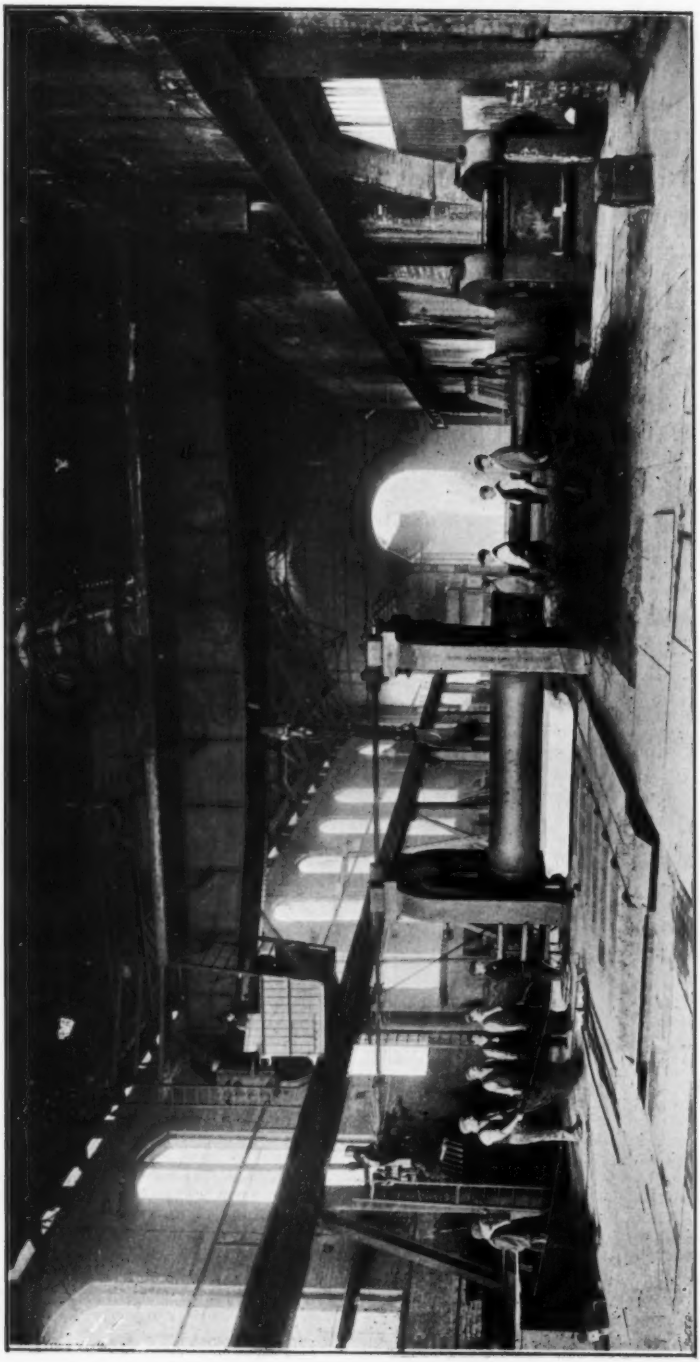


FIG. 3.—ARMOUR PLATE ROLLING MILL; VICKERS, SONS & MAXIM, LTD.

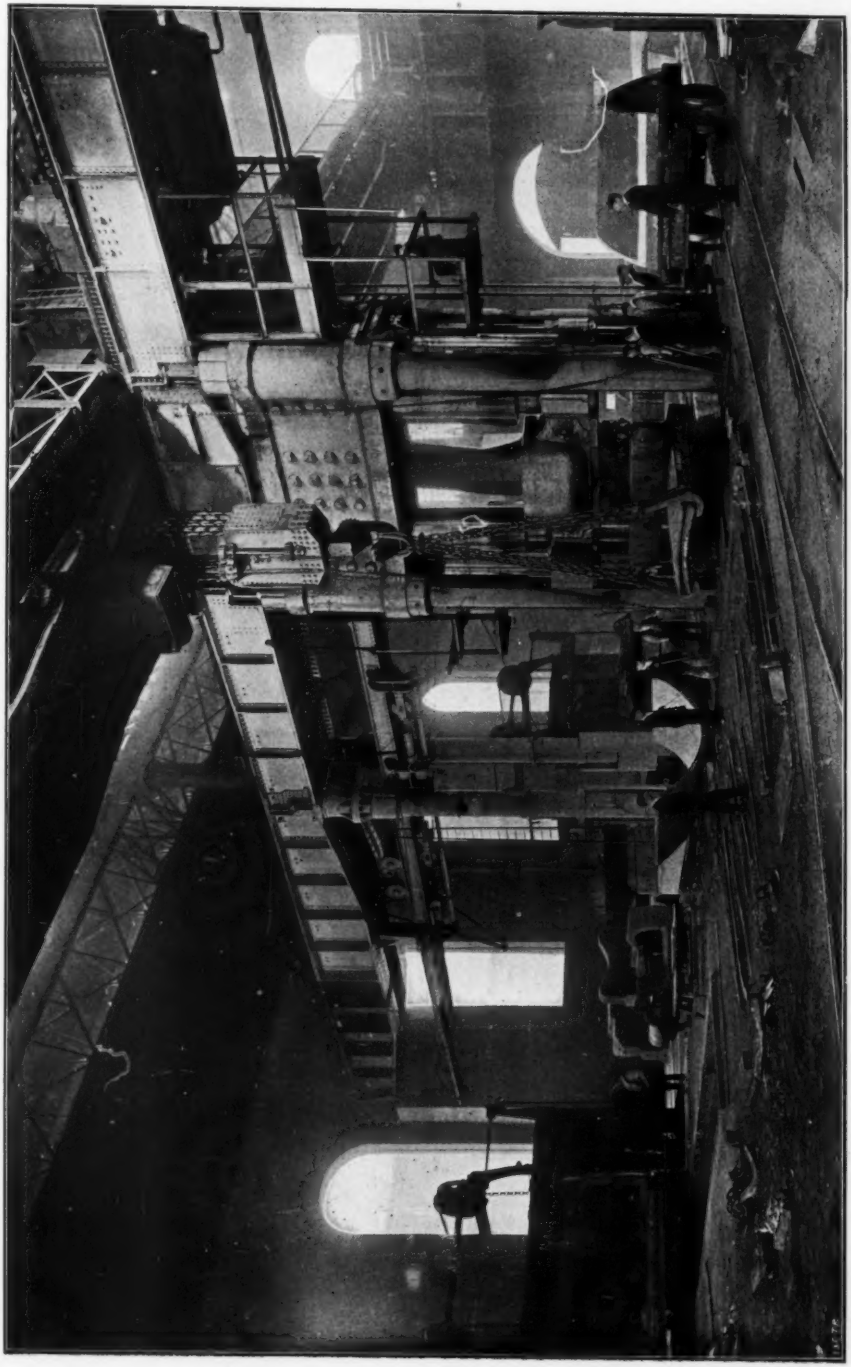


FIG. 4.—ARMOUR PLATE BENDING PRESS; VICKERS, SONS & MAXIM, LTD.

Company, after much painstaking preparation, submitted to the Admiralty a trial armour plate. At this period the plates in use were of the compound type, of wrought iron with steel face. The plate submitted by the Company was all steel, and gave better results than had been hitherto achieved in the Admiralty tests. Orders for armour for several ships followed. Later on the Company of the Naval Construction and Armaments Company, Limited, at Barrow-in-Furness. Since 1897 they have more than doubled the capacity of the works, and have erected immense shops for the construction and the building up of the mountings of all kinds of guns, for the making of all forms of projectiles, and for similar work. Figures speak for themselves, and since Messrs. Vickers took

FIG. 5.—INTERIOR OF ARMOUR PLATE PLANING SHOP, SHOWING PLANING MACHINES AND 60-TON OVERHEAD ELECTRIC CRANES; VICKERS, SONS & MAXIM, LTD.

made the first Harveyised plates in Europe, and the result being satisfactory they altered their plant to make armour hardened by that process. They also recognised the advantages of the Krupp system, and the works now have a capacity for turning out something like 10,000 tons of this class of armour per annum. Then followed the organisation of a department for the construction of the vessels for the armour and guns, and in 1897 the Company purchased the works over the works at Barrow-in-Furness the number of men employed there has increased from 5,260 to 10,300, and the wages bill from £7,550 to £17,250 per week. The area of the works has been increased from 57½ acres to 82½ acres, and the buildings now cover 25 acres, as compared with 13 acres six years ago. The Vickers' family were amongst the few who offered encouragement to Mr. (now Sir Hiram) Maxim, when he first came to this country, to carry out his experi-

ments. It was not, however, until 1897 that the Company acquired, by amalgamation, the Maxim-Nordenfeldt Guns and Ammunition Company, Limited, with works at Erith, Birmingham, and elsewhere. It was at this time, too, that the name of the firm was changed from Messrs. Vickers, Sons & Company, to Messrs. Vickers, Sons & Maxim, Limited.

It may be stated that the Company occupy a unique position, inasmuch as they are able to turn out any ship of war ready for battle without outside aid. Their 20,000 workers engaged at their various factories have the most efficient of mechanical appliances at their disposal. The great, and certainly the national, importance of the Company, will be gathered from the following list of their establishments, with the work they are equipped to carry out:—River Don Works, Sheffield, for the manufacture of armour, guns and mountings, electrical machinery, and all kinds of forgings, castings, and railway material; Naval Construction Works, Barrow-in-Furness, for the building of all types of naval and merchant ships, with their machinery, guns, and gun mountings; Ordnance Works, at Erith, for the manufacture of quick-firing, Maxim, and machine guns, with their mountings, carriages and ammunition; North Kent Iron Works, for making shot and shell; Crayford Works, for making machine guns; Birmingham Works, for making cartridge cases; Dartford Factory, for powder and ammunition; Heavy Gun Range, at Eskmeals, Cumberland, for proofs of all types of guns, and mountings, testing armour plates, etc.; Automatic and Quick-firing Gun Ranges, at Eynsford and Swanley; Placencia de las Armas Company, Spain, for the manufacture of ordnance; Wolseley Tool and Motor Car Works, Birmingham, for motor cars and small machine tools; and the Electric and Ordnance Accessories Works, Birmingham. In 1902 the Company entered into an agreement to acquire one-half of the

FIG. 6.—SOUTH GUN SHOP; VICKERS, SONS & MAXIM, LTD.

ordinary shares of Messrs. William Beardmore & Company, Limited, who own the Parkhead Forge at Glasgow, and a large shipbuilding yard at Dalmuir, between Dumbarton and Glasgow, and they have also large interests in other firms producing material required for their own manufactures.

Spread over the 50 odd acres of land at the River Don Works, Sheffield, are miles of machine shops, with hundreds of machine tools, ranging from the smallest machines to immense planers and lathes weighing over 100 tons, and costing as much as £8,000 each. An idea of the size and importance of the works may be gathered from the fact that from the Midland Railway something like seven miles of lines extend through all the departments, so that the seven locomotives within the works may distribute raw material and collect finished products for despatch. On what is known as the railway side there is the steel producing plant, where crucible as well as open-hearth furnaces are in use. There is a steel and an iron foundry, forges for the heaviest shafts, guns, etc., plant for making all sizes of guns up to 100 tons, railway tyre mills, and extensive shops for the planing of armour plate and for the machining of guns. On the river side, where the more important of later extensions have been made, there are a number of immense shops, with presses up to 8,000 tons for armour and gun work; large armour plate rolling mill, a building fitted with the appliances for the treatment and hardening of armour plate, machine shops for gun making, a large electric light station, an armour plate planing shop, an extensive department for the construction of electric dynamos, motors, etc., hydraulic presses for the forging of projectiles, with all the necessary furnaces, gas producers, etc.

Pages would be required in which to describe fully the details of the workings of this great firm at their Sheffield works. There are, of course, well-equipped joiners and pattern-makers' shops, and a large space of ground is occupied by specially devised tools for the manufacture of the bolts, nuts, and washers required for securing armour plates to the framework of a warship. This building also contains several ingenious machines which grind the edges of the armour plates after they have been hardened. These tools are contiguous to the erecting department, and here a space 70 ft. wide and 270 ft. long has been laid with 4-in. cast-iron blocks to ensure that when the plates are assembled and built up to represent a complete barbette, in which 315 tons of armour is used, or a turret weighing 230 tons, there will be no chance of the ground settling, and no interfering with the exactness of the fitting of the plates together. In making up the barbettes, two 40-ton electric overhead cranes are used, which quickly carry to the desired place plates weighing 20 to 25 tons. The area of the planing shop for armour plates is 440 ft. by 150 ft. wide, and here are immense tools for sawing plates to the required dimensions, for planing their edges and surfaces, and for drilling and tapping the holes for the bolts. There are 38 planers. Two of them are for plates up to 18 ft. long by 12 ft. wide; and ten will take plates up to 25 ft. long by 10 ft. 6 in. wide. Some of these planing machines weigh 90 tons. On one side of this large planing shop are arranged the furnaces, etc., required for the construction of large guns. These are used for bringing the component parts of the guns to the high temperature at which they are dropped into the water or oil tanks for hardening and tempering. The "Goliath" crane is noticeable here. It can lift any weight up to 100 tons, and a gun up to 55 ft. in length can be lifted with ease out of one hardening well and conveyed to another. The building which accommodates the steel producing plant is some 320 ft. by 380 ft., and contains furnaces ranging from 30 to 40 tons capacity. Each of the furnaces is charged and tapped on an average eleven times a week. After being melted the steel runs out at the other side of the furnace into ladles ranging from 50 tons capacity. In another range of buildings is some massive forging plant, with the necessary re-heating furnaces. The steam hammers range from 3 up to 8-ton; but the principal feature of the forge is a 40-in. single-ram 3,000-ton hydraulic press, used for all purposes. On the river side section of the works the most important plant is the armour-plate rolling mill and hardening furnaces, 8,000-ton forging press with all its accessories, and immense gun shops. The mill has rolls 36 in. in diameter and 12 ft. wide. When the ingots arrive at the mill they are about 36 in. in thickness in the case of the heaviest armour, and 15 in. for plates to be finished 6 in. thick. An overhead crane of 60-ton power lifts the mass of steel from the furnace cars on to the electrically-driven rollers, which feed it into the mill. At the end of this building is a 3,500-ton hydraulic press for bending armour plates after they have been rolled to the required thickness.

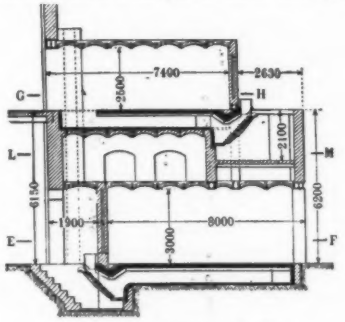
In yet another building is an 8,000-ton hydraulic forging press, served with its work at each end by cranes able to lift 150 tons. Around the press are seven furnaces for re-heating the ingots and plates. Beyond this building are eleven coal-fired furnaces, 34 ft. long and 17 ft. wide, for carburising armour plates, and in line with these furnaces there is a steel-framed building which contains four still larger furnaces, 39 ft. 6 in. in length, and 13 ft. wide, also for carburising plates. A new hydraulic forging press, with a pressure of 8,000 tons, bends the plates to any shape by an arrangement of moulding blocks placed under or over the plate. There are splendid tools in the south gun shop. Here, huge masses of steel, weighing 70 and 80 tons, are worked down with precision to suit gauges set to the 20,000th part of an inch. Enough has, perhaps, been written to show the importance of the vast undertaking of Messrs. Vickers, Sons & Maxim. It was at the River Don Works that their Majesties the King and Queen, upon their visit to Sheffield in July to open the new University, witnessed the rolling of an armour plate. ——o——

A CRANE has been specially designed by Messrs. Taylor & Hubbard, of Leicester, for two of the largest steel founders in the kingdom for picking up castings of points and crossings, and transporting them to the spot where the "lay-out" is put down on a flat floor. The crane has all its motions by steam, lifting, lowering, slewing a complete circle, and derricking the jib with or without load suspended. The main feature, however, is that it travels on a flat floor under its own steam, and is steered and turned in any direction by the driver on platform much in the same way as a motor car is driven.

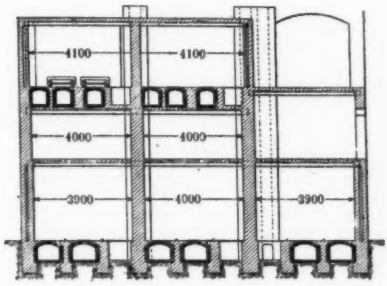
DRYING OVENS AT THE VULCAN FOUNDRY, STETTIN.

THE drying ovens at the "Vulcan" Foundry, Stettin, are five in number, three being on the ground level and supporting the other two. The three lower ovens serve for drying loam and sand moulds, and are 26 ft. long by 9 ft. 10 in. high. The width varies a little, the middle oven being 13 ft., and the two outer ones 12 ft. 9 in. each, so that the cubical capacity is 3,306 cubic feet for the latter and 3,390 cubic feet for the middle one. Each of the lower ovens contains a single rail track; and the doors, which occupy the entire front, slide up and down. The method of roofing is shown in Fig. 1, and consists of a series of H-girders supported by the side walls of the oven, the intermediate spaces being filled by arches running parallel with the girders. The outer walls of all five ovens are made hollow (Figs. 1-3), to minimise the loss of heat by radiation, and the intermediate air spaces are left unpacked. This arrangement is found to answer admirably, and the somewhat higher first cost is soon covered by the saving in fuel.

All the ovens are heated from below, the fireplaces consisting of a stepped hearth (Fig. 1), on to which the fuel is delivered through a covered feed hopper. In the lower oven, the hot gases are led through a fire-brick flue, under the oven floor, and then pass in the reverse direction through a second flue parallel to the first (Figs. 1, 2, 4, and 5). At the end of this second flue is a grated opening, through which the gases enter the oven. From the latter they pass away to the chimney through a second grated opening, situated in the opposite corner to the fire grate, carrying with them the water

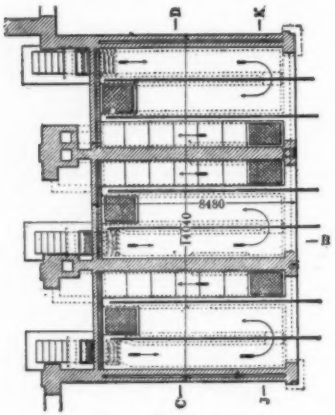


SECTION A B.
FIG. 1



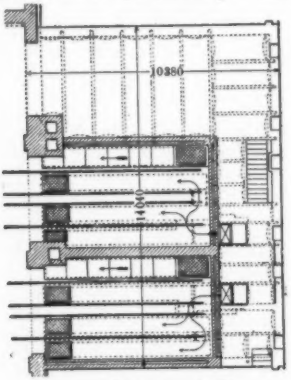
SECTION C D.
FIG. 4.

vapour from the oven through a third flue, also arranged under the floor and roofed with cast-iron plates. The draught is regulated by a damper in the chimney. The upper ovens are heated in a similar manner (Figs. 1, 3 and 4), but with this difference,



SECTION E F.
FIG. 2.

that the hot gases on leaving the grate flow through three parallel flues, discharging into the oven through an equal number of gratings (Fig. 3). From the oven they escape through a grating at the further end, and thence pass away through another flue into the chimney. The two



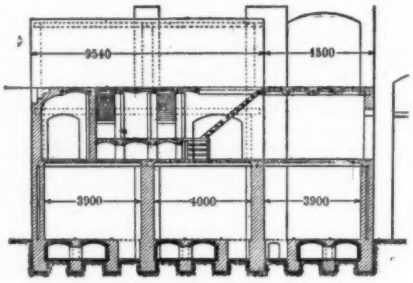
SECTION G H.
FIG. 3.

upper ovens, which are situated close to the core-makers' shop, have the following dimensions:—Height, 8¼ ft.; length, 24¼ ft.; width, 13½ ft.; the available floor space thus being 330 square feet in each, and the cubical capacity 2,670 ft.

EXPERIMENTAL DESULPHURISATION.*

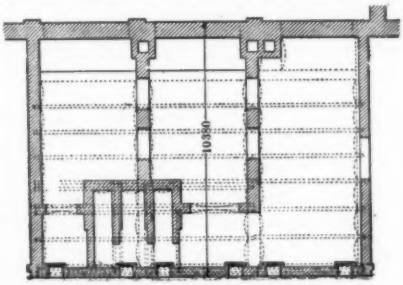
BY REGINALD MEEKS.

SULPHUR causes more trouble and injury



SECTION J K.
FIG. 5.

to iron castings when in excess than any other impurity, and yet the percentage of sulphur is lower than any of the other metalloids. It would seem to be a comparatively easy matter to remove a large portion of this injurious element, since it exists in such a small amount, but



SECTION L M.
FIG. 6.

attempts in this direction have met with the most stubborn resistance.

Limestone Proves Useless.

Some years ago the writer was con-

* From "The Iron Age."

nected with a large car wheel foundry and assisted in several attempts to reduce the percentage of sulphur in the product. The sulphur in the fuel frequently ran higher than 1.5 per cent., and consequently the castings were abnormally high in this impurity. Our castings were no exception to this state of affairs, and it was decided to try to remedy this evil by the generous use of limestone. The cupola was a large one, having a 90-in. shell lined to about 68 in., and the charge consisted of 425 lbs. of coke to 4,400 lbs. of iron, introduced into the cupola in double charges of both coke and iron.

At first 100 lbs. of crushed limestone was charged on top of each coke charge, but this had no appreciable effect on the sulphur in the iron. The stone was gradually increased until 400 lbs. were being used per charge. The test bars previous to the experiment analysed 0.210 to 0.220 per cent. in sulphur, and during the test the analysis showed from 0.208 to 0.212 per cent., or about 0.005 per cent. decrease. Even this infinitesimal amount of decrease could have been due to other causes.

On the other hand, the effect of the increase of limestone upon the lining of the cupola was disastrous. All through the trial the flame showed considerable cutting, and toward the last the shell became red hot over several thin places in the lining. The latter was so badly eaten that repairs had to be made long before the regular time. Limestone as a flux and a corrective is excellent, but as a desulphuriser is of no use, so far as the writer's experience has gone.

Experiments with Manganese Ore.

The high sulphur conditions remaining in diabolical control, another attempt to solve the problem was decided upon. From time to time articles have appeared mentioning the successful use of manganese ore in German cupola practice. So a carload of ore was brought which analysed about 40 per cent. manganese. Here was just the thing. Sulphur would combine with manganese, forming sulphide of manganese, which would naturally go off in the slag, according to some such reaction as follows :—$MnO_2 + FeS + C = MnS + Fe + CO_2$. All was clear sailing till we tried the ore. Then we found, as in the case of limestone, the results were of no value, and, moreover, were positively injurious.

As before, we started slowly, adding the ore to but ten single or five double charges. The additions were made directly on the coke, and while the experiment was on no limestone was added.

Test bar No. 7 was taken during the trial, while bars 2 to 6, inclusive, and 8 to 10, inclusive, represent the heat before and after the test. Borings from Nos. 2 to 6 and 8 to 11 were mixed and analysed, and also those from No. 7, with the following results :—

Elements.	Bars 2 to 6 and 8 to 11. Per cent.	Bar 7. Per cent.
Silicon	0.63	0.61
Manganese	0.50	0.43
Combined carbon	0.83	0.99
Graphitic carbon	2.85	2.65
Phosphorus	0.357	0.362
Sulphur	0.216	0.217

It will be observed that No. 7 shows several interesting observations—namely, there was a decided loss in manganese, the silicon remained practically unchanged, combined carbon increased 0.16 per cent., graphitic carbon decreased 0.20 per cent., the total carbon was practically unchanged, phosphorus showed no change, sulphur showed no change.

The slag was analysed for sulphur, samples being taken at three parts of the heat. Before the ore was used sulphur showed 0.320 per cent.; while the ore was used sulphur showed 0.200 per cent.; after the ore was used sulphur showed 0.290 per cent.

Although the manganese in the iron was lower during the experiment than at other times, still it carried no sulphur with it, as is shown by the analysis of the slag. The colour of the latter became very dark during the additions, due to high basicity, but lighter after the ore was stopped. However, the value of this material could not be determined by such a limited trial, so it was decided to conduct the experiment on a larger scale a few days later.

To make clear that which comes hereafter, it should be explained that a tap consisted of enough iron to pour 12 to 18 wheels, and each tap was lettered A, B, C, etc., down to Z, after which double letters were used. Also it should be understood that car wheels are measured on the circumference, about half way between the rim and the base of the flange.

A wheel, whose diameter is exactly 33 in., is called a "tape 3," and for each $\frac{1}{8}$ in. more or less the size becomes tape 4 or tape 2, etc. A tape 1 wheel, therefore, has a circumference $\frac{1}{4}$ in. smaller than a tape 3, and a tape 6 is $\frac{3}{4}$ in. larger.

The experiment was carried on with care and under uniform conditions, the details of which follow :—

The ore was added for 30 single charges, beginning with the coke charge preceding

the twentieth iron charge. Directly on the coke were charged 100 lbs. of ore and 200 lbs. of limestone. Then came the iron charge, then coke, etc. The latter consisted of 925 lbs. of a (double charge) mixture, and on the eighteenth, twenty-sixth, thirtieth, thirty-eighth and forty-sixth charges 110 lbs. extra of coke were used. As soon as the ore had descended to the melting zone, its presence began to be felt. Test pieces, or chilled blocks, showed a higher chill than normal, and at tap K the chill was so high that additions of 10 per cent. ferro-silicon had to be made to the iron in the reservoir ladle at each tap throughout the remainder of the heat. The amounts were as follows :—K and L, 30 lbs.; N, 40 lbs.; O, 40 lbs.; P, 30 lbs.; Q, 45 lbs.; R, 40 lbs.; S, 50 lbs.; T and U, 45 lbs.; V, 40 lbs.; W and X, 45 lbs.; Y, 50 lbs.; Z, 35 lbs.; AA, 40 lbs.

In all, 530 lbs. of ferro-silicon were used in the reservoir ladle, and from 2 to 4 lbs. of 80 per cent. ferro-manganese extra were used on each charge as it went into the cupola during the experiment. Test bars Nos. 5 to 9, inclusive, were taken while the manganese ore was being charged. Bars Nos. 2 to 4 represent the period before, and Nos. 10 and 11 after, the additions. Analyses were made from a mixture of bars Nos. 2 to 4 and 10 and 11, each inclusive, bars 5 to 9 and a mixture of bars 2 to 11, inclusive. The record of these analyses is shown below :—

Elements.	Bars 2 to 4 and 10 and 11. Per cent.	Bars 5 to 9. Per cent	Bars 2 to 11. Per cent.	Slag. Per cent
Silicon ...	0.63	0.55	0.60	—
Manganese	0.55	0.62	0.57	—
Combined carbon	0.76	0.83	0.80	—
Graphite carbon	2.86	2.79	2.66-2.70	—
Phosphorus	0.347	0.356	0.352	—
Sulphur ...	0.226	0.206	0.220	0.320

It will be seen that bars Nos. 5 to 9 showed a loss of 0.08 per cent. of silicon, notwithstanding the continued additions of 10 per cent. ferro-silicon. Hence, the oxidation must have been very great. The manganese, however, was higher by 0.07 per cent., due to the addition of from 2 to 4 lbs. of 80 per cent. ferro-manganese on these charges. An equal exchange of combined or graphitic carbon took place, which was to be expected when the loss of silicon is remembered. Phosphorus remained practically unchanged, since the average of the first and second column equalled the phosphorus in the entire mixture.

Sulphur was decreased 0.02 per cent., which is practically nil so far as desulphurisation is concerned, and might have been caused by a better quality of coke, scrap, or old wheels, etc., during that part of the heat.

The wheels from taps V to Z, inclusive, were under weight, and there were 13 tape 1 wheels, and the balance from these taps were tape 2. The wheels poured from the taps preceding and following experiment taped 3 and 4.

The breaking strength varied from 10 to 22 blows at 12 ft. with the 140-lb. weight. One wheel only broke at five blows. Twenty-four wheels were scrapped from taps V, W, X, and Y, mostly on account of chill depth. In some cases the chill measured 17-16 in., and the minimum was 15-16 in.

The condition of the cupola was very bad after the test. The lining was much eaten and scaffolded and was very difficult to pick out the next morning. Of limestone 1,850 lbs. were used. The blast pressure used varied from 14½ ozs. to 15½ ozs. After this trial all attempts to remove sulphur were abandoned.

Positive Methods to Obtain Low Sulphur.

The writer believes that there are only two positive methods to obtain low sulphur in iron castings—namely :—1. Use low sulphur materials throughout. 2. Use ferro-manganese in the ladles or in the cupola. That sulphur will combine with manganese when the latter is in the form of ferro-manganese and go off in the slag has been conclusively demonstrated many times.

It may prove of interest to give a few figures taken from the record of one heat :—Sulphur had been about 0.220 per cent. in the bars for a considerable period, as was stated above. On one occasion oxidation occurred to a very dangerous degree, the test chill blocks showing clear white throughout. Ferro-manganese was thrown into the reservoir ladle in great quantities There was a large loss of wheels, but the sulphur was certainly removed, as is shown by the following analyses of a bar from tap U and two wheels, one from tap S and the other from tap V. Of course, the manganese is entirely too high, but it was necessary to work fast in order to save the heat. The manganese and sulphur in both wheels and bar are shown. The result was as follows :—

	Tap.	Tape.	Blow to crack.	Blow to break.	Chill. Inch.	Manganese. Per cent.	Sulphur. Per cent.
Wheel	S	1	6	17	26-16	1.13	.167
Wheel	V	1	Tread broken / Plate not broken		28-16	1.42	.115
Bar ...	U	—	—	—	—	1.021	.13

The manganese in the bars ran from 0.50 to 0.55 per cent., and the sulphur from 0.220 to 0.230 per cent.; hence, it will be seen that the sulphur was reduced from 0.220 to 0.115 per cent. by the addition of from 0.65 to 0.70 per cent. of manganese, or nearly 50 per cent. was eliminated. However, this was an extraordinary case, and might never occur again.

In conclusion, the writer would like to suggest the publication of data relative to this very important subject, even if the experiments, like the above, should have a negative value.

HIGH AND LOW BLAST PRESSURES IN THE CUPOLA.*

By William H. Coleman.

Among the traditions handed down to us in foundry work, the high pressures deemed so essential years ago by reason of the small tuyere area and low cupolas are still adhered to by many who think the air must be discharged into the cupola with great force. Tuyere area has been increased from time to time, yet it is still believed by many of our older foundrymen that nothing but high pressure through small tuyères will carry the air to the bed of fuel. However, the excessive pressures advocated by some as a means of getting increased capacities in cupolas are not employed by modern foundrymen. From a cupola builder's circular is taken the following table, giving the highest maximum pressures usually obtainable, together with capacities :—

Table I.

Diameter inside lining. Inches.	Tons melted per hour.	Pressure in ounces.
18	½ to ½	8
23	½ „ 1	10
27	1 „ 2	10
32	3 „ 5	12
37	5 „ 6	12
42	6 „ 7	12
45	7 „ 9	14
48	9 „ 10	14
54	10 „ 12	14
60	12 „ 14	16
66	14 „ 18	16
72	18 „ 21	16
78	21 „ 24	16
84	24 „ 28	17

Very few modern foundrymen, even among users of positive blowers, care to utilise such high pressures for several reasons. 1, They find they can get their required capacities at the lower blast pressures; 2, the cupola lining will last longer under lower pressures; 3, oxidation of the silicon and manganese is greater under the high pressures, and this is only compensated by paying more for high silicon grades; 4, the resultant castings are smoother and easier to machine when made under the lower pressures; 5, there is less liability to slag under the lower pressures; 6, greater strength in castings is obtained in melting by the lower pressures; 7, the horse-power required per ton melted is less at low pressures than at high pressures.

* Abstract of a paper read before the Philadelphia Foundrymen's Association, November 1, 1905.

A Large Melter Favours Low Blast Pressure.

Among the foundrymen who, under the direction of their chemists, have been reducing their pressures from time to time, it is significant that a company in Chicago operating the largest number of cupolas, as well as the largest in size, is the firmest believer in low blast pressures. It is now installing two cupolas of 84 in. inside diameter and a centrifugal fan blower to give 24,000 cubic feet of air per minute at 10 to 12-oz. pressure in the wind box of the cupola. The great fluidity of the iron, the quality of the castings produced, together with the capacities and low horse-power per ton of iron melted, certainly seem to prove the claims for low blast pressure. The large tuyere area, together with the ample area of blast supply pipe, is an important and valuable feature of this installation.

Many foundrymen have found it desirable to increase tuyere areas all the way up to 25 per cent. of the area of the cross section of the cupola. In connection with low pressures a liberal volume of air is equally important. Many foundrymen are using blowers whose ordinary capacity is far below the required volume; therefore, they are compelled to speed up their blowers in order to get the necessary volume and thereby get incidentally higher pressures than are essential, with poor results in product and rapid destruction of cupola lining. Even with limited cupola capacity the loss in melting capacity at the cupola with low pressures is more than made up in the machine shop. Low pressures produce a soft casting easy to machine, since there is less loss of silicon and manganese by oxidation. For the same reason higher strength is obtained under low pressures. as has been proved by tests.

Volume a Function of Size and Melting Ratio.

It has been found that the volume of

air required to melt a ton of metal per hour depends upon the size of cupola and the ratio of coke to metal used in melting. In a cupola air is blown over the melted metal, not through it. The oxidation of carbon is slight and incidental, not fundamental and complete, as in a converter when air is blown through the metal. The following volumes are approximately correct for air required per ton melted per hour :—

6 lbs. iron to 1 lb. coke, 83,000 cubic feet air per ton per hour.
7 lbs. iron to 1 lb. coke, 31,000 cubic feet air per ton per hour.
8 lbs. iron to 1 lb. coke, 29,000 cubic feet air per ton per hour.
9 lbs. iron to 1 lb. coke, 27,000 cubic feet air per ton per hour.
10 lbs. iron to 1 lb. coke, 25,000 cubic feet air per ton per hour.

To get a greater volume at the same pressure requires a larger size pipe. It is therefore apparent that increased tuyere area and properly proportioned supply pipe and ample area in the wind box are desirable for low pressures. Inversely, when the former are too small higher pressures are required to obtain the volume necessary. Now, having a cupola of sufficient capacity with a total tuyere area equal to 20 per cent. of the circumferential area measured inside, and with the blower delivering the required volume through a pipe whose area is not less than one-third of the combined tuyere area and a proportional area of wind belt, we can get ideal conditions for using low pressures, particularly if the tuyeres are properly placed for the product desired. We would then have the melting capacity shown below :—

Table II.

Inside cupola diameter. Inches.	Capacity per hour. Tons.	Pressure in ounces.
18	½ to ¾	½ to 7
23	¾ „ 1½	5 „ 7
30	2 „ 3½	6 „ 8
35	3 „ 4	7 „ 8
37	4 „ 5	7 „ 10
42	5 „ 6	7 „ 10
45	6 „ 7	8 „ 10
48	7 „ 8	8 „ 10
54	8 „ 9½	9 „ 10
60	10 „ 12	10 „ 12
66	12 „ 15	10 „ 12
72	16 „ 18	10 „ 12
78	19 „ 22	12 „ 14
84	21 „ 24	12 „ 14

From a number of cards showing low pressures and representing the practice of some of our best foundrymen the figures in Table III. are taken, representing different classes of work, and both fans and pressure blowers.

Running a blower, particularly of the centrifugal fan type, beyond its volume capacity and thereby producing excessive pressure by reason of too small a blower and decreased tuyere area, I consider the most grievous fault in cupola practice.

—o—

THE WADSWORTH IMPROVED CORE MACHINE.

One feature of the Wadsworth improved core machine is that it can successfully produce large standard cores. Machines of the same type have been put on the market, but have never been successful in producing cores of a greater diameter than 2¼ in., whereas in the Wadsworth improved core machine any size of core up to 7 in. diameter can be successfully produced. The standard size of machine comprises a set of dies, and conveyor screws for round cores, varying in diameter by eights from ⅜ to 2¼ in., and above these sizes any size dies and conveyor screws can be applied suitable for cores up to 7 in. in diameter, square, oblong, and hexagonal. Also "T" shape cores used in the tables of milling and planing machines and similar tools. Cores of this type have been successfull made in lengths up to 3 ft. and upwards, and although it is not recommended to use the machine commercially for making cores over 4 ft. in length, yet cores of 7 in. diameter have been made 6 ft. long, and cores 6 in. in diameter as long as 10 ft. 6 in.

The machine turns out one core of any size between ⅜ in. and 2¼ in., 40 in. and upwards in length, every minute, after having made due allowance for change of plates, etc. All cores made on this machine are one piece cores.

The following is a record of cores made on a Wadsworth improved core machine,

Table III.—Results of Tests with Low Blast Pressures in Foundry Cupolas.

Test.	Inside diam. In.	Time. Hours.	Capacity. Tons.	Melting ratio.	Blower.	Pressure. Ozs	Average h.-p. per ton per hour.	Scrap. Per cent.	Castings.
6	42	1½	10	6 to 1	Fan.	7½ to 10	2.25	0	Small soft.
11	45	1½	12	10.8 to 1	Fan.	6½	1.70	50	Medium soft.
12	60	2	14	5.6 to 1	Fan.	9	4.21	50	Heavy engine.
15	48	1½	9	8 to 1	Fan.	12	3.66	50	Light stove.
23	48	1½	7	7 to 1	Fan.	11	2.5	50	Light stove.
24	60	1½	13	7 to 1	P.B.	8 to 11	4.86	20	Light stove.
46	40	1¼	6½	7 to 1	P.B.	8 to 13	—	30	Medium soft.
49	72	2½	22½	8.9 to 1	P.B.	4 to 6	3.41	—	Sewing mach.

FIG. 1.—WADSWORTH CORE MACHINE, SHOWING DIES, CONVEYOR SCREWS, COUNTERSHAFT, CORE TRAYS, AND VARIOUS SIZES OF ROUND, SQUARE, AND HEXAGONAL CORES.

running 300 revolutions per minute. The output depends upon the speed the machine is run. The screw of the machine makes three turns to one of the hand wheel or pulley on all sizes up to 2¼ in.; all above, one revolution of screw to one revolution of pulley.

Feet	Core. In.	Feet.	Core. In.
220	2½	504	1½
200	2¼	576	1¼
272	2	600	1
288	1¾	550	¾
336	1½	520	
360	1¼	468	
360	1¼	240	½
432	1¼	216	¾

Not only for rapidity of production does the Wadsworth core machine rank high, but it makes a cored hole equal to a bored one. The core can be cleaned out with a lead pencil. No core boxes are required, or ramming of sand by hand, and no paste is used, thereby saving flour and time. There is a saving in oven space, as the cores are one piece, and less breakage, as they are stronger. It is also claimed that a core made by this process does not swell as is the case with cores made by the old method.

Upon a basis of an expenditure of 5d. for wages, and a production from 200 to 600 ft. of core per hour, the Wadsworth machine will make from 40 to 120 ft. of finished core for 1d.

The great secret of using one of these machines successfully is to give particular attention to the correct grade of sand suitable for the purpose.

Messrs. J. W. Jackman & Company, of 39, Victoria Street, S.W., who are the sales agents, inform us that machines of this make are now in successful use in many of the most up-to-date foundries in the United Kingdom.

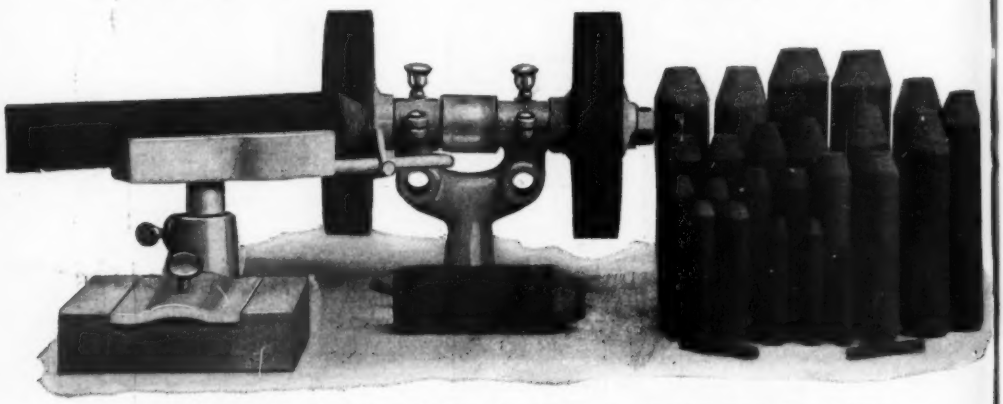


FIG. 2.—WADSWORTH IMPROVED CONING ATTACHMENT, COMPLETE WITH TWO EMERY WHEELS AND WITH TWO RESTS SO AS TO ALLOW BOTH ENDS OF CORE TO BE CONED, ONE LONG AND ONE SHORT END, WITHOUT CHANGING RESTS.

TRADE TALK.

VICKERS, SONS & MAXIM, LIMITED, are adding a tube-making plant to their Naval Construction Works, at Barrow.

THE WILSONS AND UNION TUBE COMPANY, LIMITED, have re-started their Govan Works.

THE ENGINEERING STANDARDS COMMITTEE have issued their report on standard locomotives for Indian railways.

BRUCE, PEEBLES & COMPANY, LIMITED, have removed their London establishment to 1, London Wall Buildings, E.C.

MR. G. A. GOODWIN, consulting engineer, has removed from 28, Victoria Street, London, S.W., to 25, Victoria Street, S.W.

THE business of Messrs. A. Edmeston & Sons has been removed to the Springfield Engineering Works, Patricroft, Manchester.

MESSRS. J. R. REEDMAN, P. J. TYE, and R. WORLEY, engineers, Acre Lane, Canning Town, E., have dissolved partnership so far as regards Mr. R. Worley.

M. COCKBURN & COMPANY, LIMITED, has acquired the business of M. Cockburn & Company, ironfounders, of the Gowanbank Iron Works, Falkirk.

MESSRS. WRIGHT, BUTLER & COMPANY, of Cwmavon, are extending their works.

AT the works in North Staffordshire of the Knutton Iron Company, extensive developments are in progress.

THE UNDERFEED STOKER COMPANY, LIMITED, have established a branch at Baltic Chambers, 50, Wellington Street, Glasgow.

A RECEIVING order has been made in connection with the affairs of F. Woodward & Company, engineers, Clerkenwell, London, E.C.

HAMMON & SMITH, LIMITED, has been registered with a capital of £2,000 in £1 shares, to carry on the business of engineers, etc.

F. E. BAKER, LIMITED, has been registered with a capital of £2,000 in £1 shares, to carry on the business of ironfounders, etc.

THE BRITISH UNITED ENGINEERING COMPANY, LIMITED, of 175, Piccadilly, W., has been formed with a capital of £10,000 in £1 shares.

THE PHŒNIX ENGINEERING COMPANY, LIMITED, has been registered with a capital of £4,000 in £1 shares, with offices at Chard, Somerset.

THE RELIANCE BRASS AND IRON FOUNDRY COMPANY LIMITED, of Newton Chambers, 43, Cannon Street, Birmingham, has been formed with a capital of £500.

MR. G. C. VYLE, of the General Electric Company's Works, at Salford, has established himself in business as a consulting engineer, at 14, Ridgefield, Manchester.

MESSRS. W. SCHWARZ and H. R. COUPER, mechanical engineers, etc., Liverpool, trading under the style of Couper, Schwarz & Company, have dissolved partnership.

THE business of the Ryknield Engine Company Limited, of Burton-on-Trent, will be taken over by a new company, probably to be known as the Ryknield Motor Company.

THE works of J. & S. Roberts, ironfounders, of Swan Village, West Bromwich, are not to be immediately closed, but will be carried on for the time being by the receiver appointed.

THE MOND POWER GAS COMPANY have connected up to the works of Bayliss, Jones & Bayliss, who have recently extended their structural iron and steel department.

MR. B. S. GILES has been appointed by Mather & Platt, Limited, as chief representative for London and the South of England of their electrical and hydraulic departments.

MR. G. F. WHEELER has given up his position in the engineers' office of Cammell Laird & Company, Limited, Sheffield, and has started in business as a consulting engineer.

MESSRS. C. W. E. MARSH, R. LAYBOURNE, and A. H. LAYBOURNE, of the Isca Foundry, Newport, Monmouthshire, have dissolved partnership, so far as regards Mr. C. W. E. Marsh.

MR. R. TOWNSEND, engineer, Victoria Works, Sorby Street, Sheffield, has been adjudged bankrupt, with liabilities to the amount of £1,465 9s. 5d., and an estimated surplus of £986 7s. 2d.

THE BATH ENGINEERING COMPANY, LIMITED, has taken over the businesses carried on at Bath by M. L. Sykes as the Wiltshire Engineering Company, and by E. C. Matthews, under his own name.

A LECTURE was delivered recently before the Leeds Association of Engineers, by Mr. R. Buchanan (the President of the British Foundrymen's Association), on "The Melting and Cooling of Cast Iron."

THE DIESEL ENGINE COMPANY, LIMITED, have entered into agreements with Messrs. Willans & Robinson, the well-known engine builders, of Rugby, to produce engines for the company on favourable terms.

BILLINGTON & NEWTON, LIMITED, has been formed with a capital of £80,000 in £1 shares, to carry on the business of metal workers, ironfounders, etc., at the Vulcan Metal Works, Longport, Staffordshire.

J. B. EDLINGTON & COMPANY, LIMITED, is the name of a company formed to carry on the business of engineers, etc., at the Phœnix Iron Works, Lea Road, Gainsborough, Lincolnshire. The capital is £17,000.

MESSRS. WALTER SOMERS & SONS, of Haywood Forge, Halesowen, Worcestershire, have erected a forging press weighing nearly 400 tons and capable of exerting a pressure of 3,000 tons, at their works.

MESSRS. GEIPEL & LANGE, of 72A, St. Thomas Street, London, S.E., have been appointed sole representatives in Great Britain for M. F. Henrion, of Nancy, for the sale of his dynamo and motor carbon brushes, etc

A RUMOUR has gained currency that the shareholders of the Ebbw Vale Steel, Iron and Coal Company, Limited, and Guest,

Keen & Nettlefolds, Limited, are being approached with a view to amalgamating the two concerns.

THE shareholders of Messrs. Graham, Morton & Company, Limited, have decided that the company cannot, by reason of its liabilities, continue its business, and that the company accordingly be wound up voluntarily.

AT a meeting of the creditors of Messrs. John Beatson & Son, at Derby, recently, it was resolved that the meeting be adjourned until January 17, to enable pending negotiations for the sale of the debtors' business to proceed.

THE STANDARD GAS ENGINE COMPANY, LIMITED, has been formed with a capital of £10,000, in £1 shares, to acquire the business of the Standard Oil Engine Company, Preston, Lancs. The registered office is at 9, Chapel Street, Preston.

JOHN BROWN & COMPANY, LIMITED, have just completed the first of four large turbine drums for the Cunarder which they are building at Clydebank. The forging weighs 15 tons, and is approximately 12 ft. in diameter and 8 ft. long.

MR. G. WUTHRICH, of Oswaldestre House, Norfolk Street, Strand, W.C., has been appointed manager for Great Britain and the Colonies and London resident engineer, for the Maschinenfabrik Oerlikon, of Oerlikon, Switzerland.

AT Aberdare Bankruptcy Court, recently, Richard Lewis, ironfounder, Aberdare, appeared for his public examination. Debtor stated that his liabilities amounted to £3,000, and his assets to £1,157. The examination was adjourned.

THE BRITISH THOMSON-HOUSTON COMPANY, LIMITED, is associated with the Allgemeine Elektricitats Gesellschaft in the latter company's tender to the London, Brighton and South Coast Railway for the electrification of certain of its lines.

THE LANCASHIRE HEATING COMPANY, LIMITED, of Walsall, has acquired the business of heating engineers, carried on by the Lancashire Heating Company, at Birmingham, and the business of the Sackville Engineering Company, at Manchester.

THE HOLWELL IRON COMPANY, LIMITED, of Asfordby, Melton Mowbray, has received the contract for cast-iron pipes, cylinders for pump well, and fittings, in connection with the Etton Extension Corporation Waterworks for the city of Peterborough.

AT the Brightside Foundry and Engineering Company's Newhall Works, Sheffield, an exceptionally large ingot mould casting, for a gun forging, has been completed to the order of Messrs. Cammell Laird & Company, Limited. The weight of the metal was 84 tons, and the dimensions of the casting were 15 ft. by 8 ft. 6 in.

CONSIDERABLE improvements are being carried out at the Old Park Works, Wednesbury, of the Patent Shaft and Axletree Company, Limited. A new smiths' shop, 200 ft. by 50 ft. in one span, and new pattern shops and stores (250 ft. by 60 ft.) are nearly completed. The old foundry has been enlarged to 250 ft. by 60 ft. in two spans.

THOMAS SUMMERSON & COMPANY, LIMITED, have acquired the York Street Works at Darlington, formerly occupied by the Darlington Wagon and Engineering Company, Limited. The Alliance Works, which belonged to the same company, have, we understand, been purchased from the debenture holders by the Blake Boiler, Wagon, and Engineering Company, Limited.

ED. BENNIS & COMPANY, LIMITED, of Little Hulton, Bolton, are supplying Clarke, Chapman & Company, Limited, Gateshead-on-Tyne, with one set of "Bennis & Miller-Bennett" chain grates, and the Patent Shaft and Axletree Company, Limited, Wednesbury, Staffs., with 46 stokers and compressed air furnaces, with complete coal and ash-handling plant, for their various works at Wednesbury.

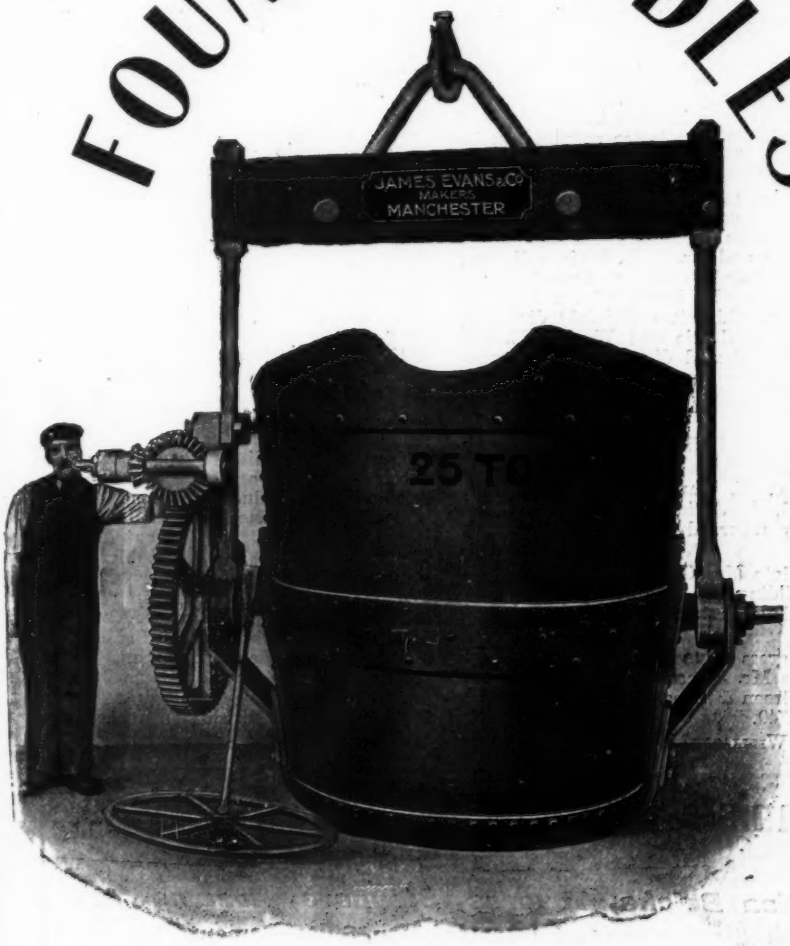
AT West Bromwich, recently, the case of Messrs. H. P. F. F. Bertrand, J. H. Bertrand, and L. V. Bertrand, who formerly carried on business as brass and ironfounders under the style of P. H. Bertrand & Sons, at the George Street Works, West Bromwich, was resumed. J. H. Bertrand having left the country, his public examination was adjourned *sine die*, and a warrant was issued for his arrest.

THE highest award for mechanical stokers, consisting of the only silver medal, has been awarded to Ed. Bennis & Company, Limited, Little Hulton, Bolton, by the Smoke Abatement Society, for their mechanical stoker and self-cleaning compressed air furnace exhibited at the recent exhibition. Messrs. Bennis also obtained a bronze medal for their new chain grate (Bennis-Miller-Bennett patent).

EDWARD G. HERBERT, LIMITED, of Manchester, have in hand for the Admiralty

Contractors to H.M. Government.

FOUNDRY LADLES



JAMES EVANS & Co., FOUNDRY ENGINEERS,

Telegrams:
"LADLES, MANCHESTER."

BRITANNIA WORKS, MANCHESTER.

three full-automatic circular sawing machines for cutting brass and copper bars and tubes up to 3 in. diameter. These machines feed the bar forward and make successive cuts automatically. Other orders from the Admiralty include a "Git" sawing machine for gun-metal castings, and two No. 3 eccentric sawing machines for cutting steel bars, etc., up to 20 in. by 12 in.

THE recent interchange of shares between Messrs. Cammell, Laird & Company, of Sheffield, and the Fairfield Shipbuilding and Engineering Company, of Govan, whereby Messrs. Cammell, Laird secured a large interest in the Fairfield Company, and the latter acquired an interest in Messrs. Cammell's Ordnance Works at Coventry, has now been followed by an interchange of directors of the two concerns. Mr. J. MacGregor Laird, the chairman of Cammell, Laird & Company, and Mr. R. R. Bevis, a director of the Sheffield company, have been appointed to the board of the Fairfield company, while two Fairfield directors, Messrs. A. Gracie and W. M. Rhodes, have been elected directors of Cammell, Laird & Company.

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PERSONAL.

MR. T. W. WARD, of Thos. W. Ward, Limited, the Albion Works, Sheffield, has recently returned from a visit to South Africa.

THE late Mr. G. J. Cole, of Earle's Shipbuilding and Engineering Company, Limited, left estate of the gross value of £4,220.

THE gross value of the estate left by the late Mr. James Scarlett, of the firm of E. Green & Sons, Limited, amounted to £61,749.

SIR WILLIAM MATHER recently presented certificates to the successful students at the Crystal Palace School of Engineering.

MR. S. MARTIN, of the Cardiff-Dowlais Works, has been appointed general manager of the Yorkshire Iron and Steel Company, Penistone.

THE late Mr. T. Bradford, head of Messrs. Bradford & Company, Crescent Iron Works, Manchester, left estate of the gross value of £39,110.

THE late Mr. A. Macdougal, of George Christie, Limited, brass and copper wire drawers and weavers, of Govan, has left personal estate of the value of £32,877.

MR. J. COWAN has resigned the managing directorship of the Stirling Boiler Company, Limited, who have appointed Mr. E. G. Constantine, of Manchester, to be managing director. Mr. Cowan still retains his interest in the company, and will continue to be the chairman.

MR. G. FRASER, who established the Nova Scotia Steel and Forge Company and the Nova Scotia Steel and Coal Company, and later became general manager of the Dominion Iron and Steel Company, has retired. Mr. F. P. Jones has been appointed to succeed Mr. Fraser as general manager of the Dominion Company.

THE customary list of honours in connection with the resignation of the late Prime Minister includes the names of two well-known gentlemen connected with the iron trade, viz., Sir Henry Meysey-Thompson, Bart., M.P., and Mr. J. S. Randles, M.P. Sir Henry Meysey-Thompson, who has been created a baron, is a director of the Barrow Hematite Steel Company, while Mr. J. S. Randles, M.P., one of the new knights, is the chairman of the Moss Bay Hematite Iron and Steel Company, Limited, and was President of the British Iron Trade Association in 1903-4.

Ganister, Cupola Blocks, Fire Bricks,
Fire Clay.
Silica Bricks, Tuyeres, Stoppers, Nozzles, &c.
Steel Moulders' Composition, Silica Cement.

J. GRAYSON LOWOOD & Co., Ltd.,
DEEPCAR, nr. SHEFFIELD.
Telegrams: "LOWOOD, DEEPCAR."

ELDERS FOUNDRY COKE

As supplied to the British . . Admiralty Dockyards.

The following, selected from numerous letters, are eminent testimony as to the quality of our celebrated "A.A.A." Coppee Foundry Coke, carefully selected, and despatched in sheeted wagons.

From PECKETT & SONS, Bristol.

Bristol, October 25th, 1904.

We have been using your Selected Foundry Coke for some considerable time.

We have pleasure in stating that we are very pleased with it, as we find we get sounder and cleaner castings, more free from blow-holes and other defects, than we formerly did.

From MOUNTFORT PHILLIPS & Co., Llantrissant.

Llantrissant, October 25th, 1904.

In reference to the Foundry Coke you have been supplying us with for the last six months, we have very great pleasure in letting you know that it has given every satisfaction, and that our Works Manager and Workmen give it the highest praise.

Elders Navigation Collieries, LTD. Cardiff.

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HAVE YOU A GOOD LIST OF FOUNDRIES, IRON, STEEL, ENGINEERING WORKS AND COLLIERIES?

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If you are desirous of pushing your business in the Colliery, Iron, Steel, Tinplate and Engineering Trades, either as Producer, Manufacturer, Merchant, Agent, Traveller, etc., it would prove most valuable to you.

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OBITUARY.

Mr. E. John, manager of the Gloucester Wagon Works, at 62 years of age.

Mr. J. A. Syme, formerly one of the directors of the firm of Stewarts & Lloyds, Limited, Glasgow, at the age of 55 years.

Mr. G. Evans, of Llanelly, chairman of directors of Richard Nevill & Company, owning one of the oldest of local foundries.

Mr. M. Dent, who formerly had charge of the forging department at Palmer's shipyard, and was also founder of Dent's Forge Company. Later, he occupied the position of manager of Fowne's Forge and Engineering Works, Cardiff.

Mr. R. Mansel, late of the firm of Messrs. Aitken & Mansel, shipbuilders, Whiteinch, Glasgow, and one of the founders of the Institution of Shipbuilders in Scotland, now merged in the Institution of Engineers and Shipbuilders.

Mr. H. W. Chubb, grandson of the late Charles Chubb, the inventor and patentee of the well-known Chubb lock. Mr. H. Chubb served a term of apprenticeship to Simpsons', the engineers, of Pimlico, and then became a managing director of Chubb and Son's Lock and Safe Company, Limited, of which his brother, Sir George Chubb, is chairman.

QUERIES.

"I am thinking of making crucibles suitable for melting Admiralty gun-metal, and would be much obliged if you could give me a suitable mixture, through the medium of your valued paper.—Piper."

Casting Bronze Round an Iron Centre.—"D. B." writes:—"We have tried casting a number of gun-metal and also phosphor bronze rings round a cast-iron centre, which we heat to a dark red before pouring around our bronze or gun-metal. These rings vary from 12 in. diameter to 5 ft. diameter, and from 1 in. to 3 in. in thickness, and 2 in. to 6 in. in width. We have deep grooves to cut into these rings, but have been sorely troubled with their showing blow-holes when we machine down into them. Is there any way of overcoming this?"

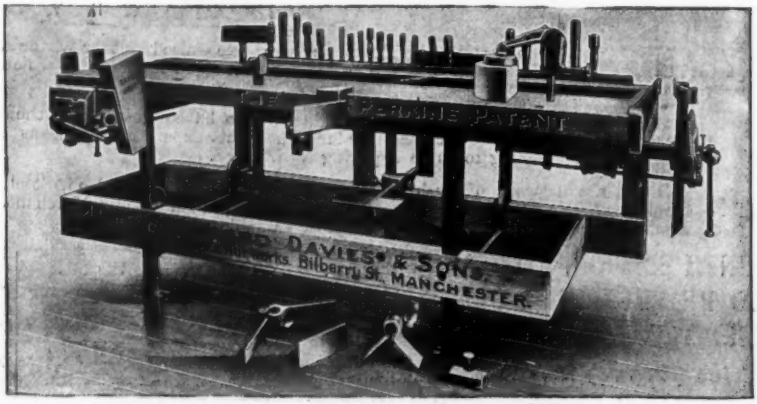
——o——

Wm. Beardmore & Company, Limited, are erecting a gun-tempering shop in their gun manufacturing department which they are adding to their works at Parkhead. It is stated that negotiations are proceeding which will probably end in the absorption of the Carron Company by Messrs. Beardmore.

EFFICIENCY! ECONOMY!

THE "PERKINS" PATTERN MAKERS' BENCH.

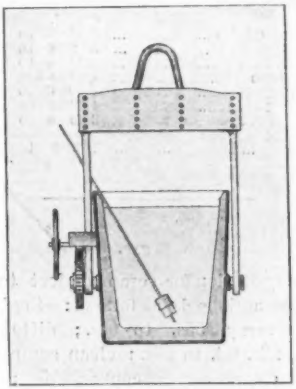
Designed and Built by a Pattern Maker.



ADVANTAGES

GRIPQUICK VICE. Movable Tool Rack. Simplicity. All Attachments (interchangeable) adapting themselves to any shape of work. Low Price.

PREVENTION OF BLOWHOLES IN CAST IRON.



A tin of our special compound fixed on a rod is held at bottom of ladle as shown; a strong re-action being thereby set up frees the iron from gases and impurities, which rise to the top.

RESULT: A denser casting of finer grain with increased strength.

For Particulars apply to—

THERMIT LIMITED,

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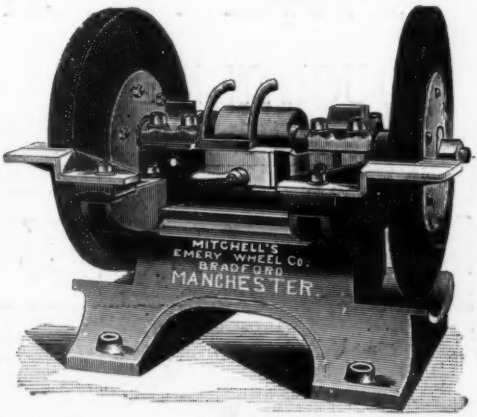
Telephone—3749 Central.
Telegrams—"Fulmen," London.

LONDON, E.C.

MACHINES. For all Purposes. **WHEELS.**

Complete with Emery or Corundum Wheels from **£2** upwards.

Special Machines Designed.



Emery or Corundum from 1 in. x $\frac{1}{8}$ in. to 50 in. x 12 in.

Enquiries solicited.

MITCHELL'S EMERY WHEEL Co.,

Mill Street, Bradford, MANCHESTER.

Also at LONDON, GLASGOW, and BELFAST.

LISTS FREE.

PRICES OF METALS.

The following table shows the approximate latest prices and position of stocks of metals during the past two years :—

METALS.	1905-6.	1904-5.
Iron—Scotch pig warrant ... ton	—	—
—Middlesbro' warrants ... ... ton	54/1	49/6
—W.C. M/nos Bessemer ... ... ton	72/9	53/6
—Stock, Scotch, Dec. 30 ...tons	15,600	11,000
Copper—Chili bars, GMB ... ... ton	£79 10/0	£68 2/6
—Stock, Europe & afloat... ... tons	12,983	16,734
Tin—English ingots ton	£167 0/0	£134 15/0
—Straits ... ton	£163 0/0	£134 10/0
—Stock, Ldn. Hind and afit ... tons	13,501	14,686
Lead—English pig ton	£17 15/0	£13 7/6
Spelter—Ord. Silesian ... ... ton	£29 7/6	£25 2/6
Quicksilver—(75lb.) bottle	£7 5/0	£7 15/0
Antimony—Regulus ... ... ton	£62 0/0	£40

CASTINGS.

In the Cleveland district the following are the nominal rates current for castings :—

	£ s. d.		£ s. d.
Columns (plain)	6 12 6	to	7 2 6
Pipes, 1½ to 2½ in.	5 2 6	to	5 5 0
,, 3 to 4 in.	4 15 0	to	4 17 6
,, 5 to 8 in.	4 12 6	to	4 15 0
,, 10 to 16 in.... ...	4 12 6	to	4 15 0
,, 18 to 24 in.... ...	4 12 6	to	4 15 0
Chairs	3 15 0	to	3 17 6
Floor plates (open sand)	3 2 6	to	3 5 0

SCRAP.

The quotation for scrap subject to market fluctuations is as follows :—Engineers' heavy scrap, 55s. to 60s.; ditto light scrap, 22s. 6d. to 25s.; clean scrap brass, 46s.; clean scrap copper, 75s.; lead (usual draft), 15s. 9d.; tea lead, 14s. 3d.; zinc, 22s. 9d.; hollow pewter, 105s.; black pewter, 70s. per cwt.

SILICA FIRE BRICK Co.,

OUGHTIBRIDGE.

GROUND GANISTER,

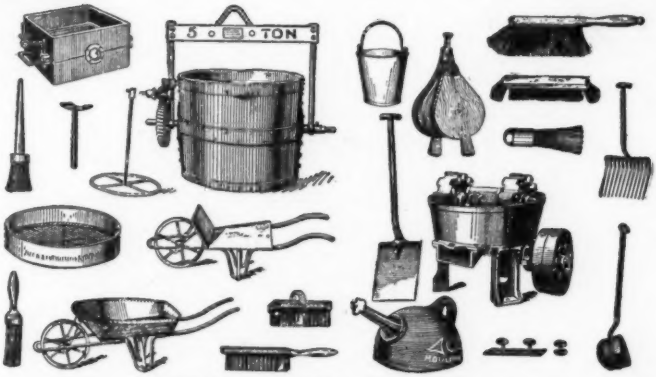
Wet or Dry.

Silco Cupola Bricks, 90 % Silica.

Better than Fire-clay Bricks for Cupolas.

Established 1863.

Jas. Durrans & Sons,



PHŒNIX WORKS, PENISTONE,

Nr. Sheffield.

Manufacturers of all

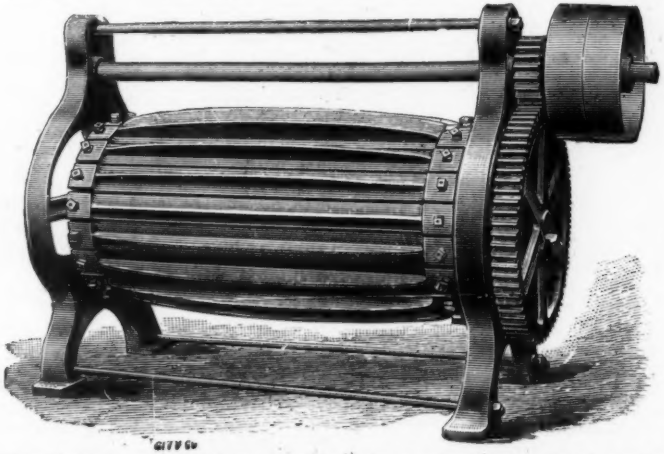
FOUNDRY EQUIPMENTS

Composition Black Lead,

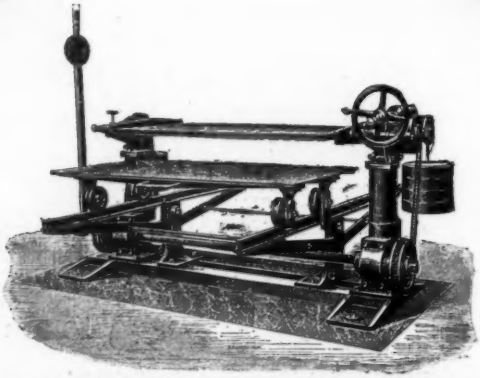
Plumbago, Core Gum, White Dust, and Coal Dust.

Ladles, Cupolas, Fire Bricks, Gannister, Stone Flux, Loam and Sand Mills, Casting Cleaners, Studs, Chaplets, Pipe Nails, Sprigs, Brushes, Wire Brushes, Core Ropes, Bellows, Buckets, Spades, Forks, Riddles, Sieves, Barrows, &c.

IMPROVED FOUNDRY RATTLER or FETTLING DRUM.



These Machines are invaluable for a Foundry, doing a larger amount of work of a superior quality, in a much shorter time than can be done by hand, without skilled labour.



TURN-OVER HAND MOULDING MACHINE,

PATTERN "G."

Arranged with Worm Gear for turning plate for large boxes.

SAND Drying Stoves.
Grinding Mill with Sifter.
Mixers and Sifters.

Core Making Machines and Core Ovens.

MOULDING MACHINES

For Hand, Hydraulic, Steam or Air.

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Telephone: 99 Tottenham.
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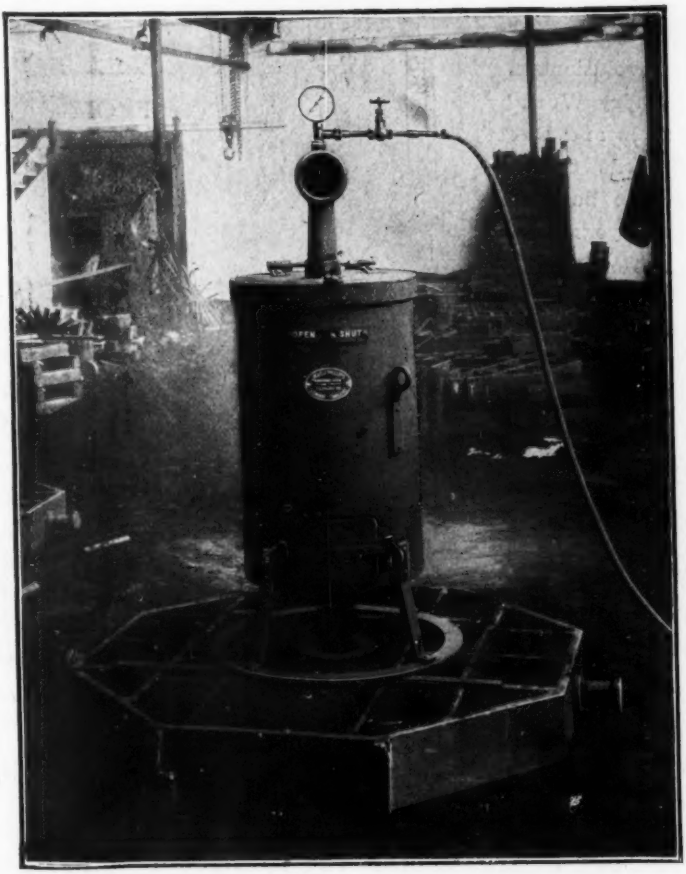
Park, Tottenham, LONDON, N.

The NEW

Portable Mould Drier

The Latest Foundry Time Saver.



J. W. & C. J. PHILLIPS,

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23, COLLEGE HILL, LONDON, Eng.

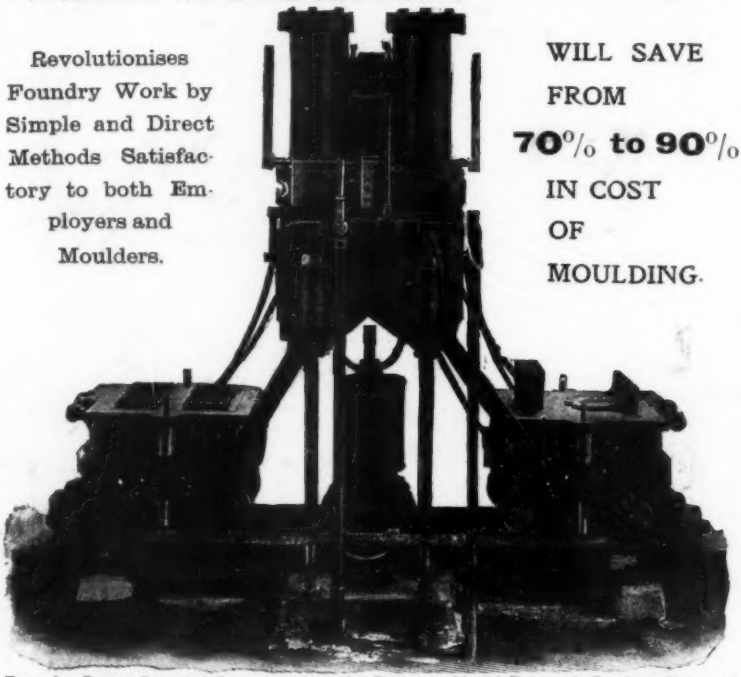
Telegrams: "COLLOQUIAL, LONDON." Telephone: 10122 CENTRAL.

THESE MACHINES MAY BE ***RENTED.***

The McClelland Patent

SAND MOULDING MACHINE

Revolutionises Foundry Work by Simple and Direct Methods Satisfactory to both Employers and Moulders.



WILL SAVE FROM **70% to 90%** IN COST OF MOULDING.

Type A.—Power Operated Carriage run under Rammer, Mould Rammed, Carriage Returned and Box Lifted, all Automatically. Arranged for one or two men to work continuously.

NO OTHER SAND MOULDING MACHINE HAS THE SPEED, SIMPLICITY AND STRENGTH OF THIS.

TURNS OUT BETTER MOULDS AND CASTINGS THAN BY HAND.

THE SAFETY TREAD SYNDICATE,

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Telephone, 5646 Bank. **Telegraph, "Unslipping," London.**

NOTICE.

CARNEGIE RESEARCH SCHOLARSHIPS.—The Council of the Iron and Steel Institute will shortly proceed to award Research Scholarships founded by Mr. Andrew Carnegie. Candidates, who must be under 35 years of age, must apply before 28th February on special forms to be obtained from BENNETT H. BROUGH, Secretary, Iron and Steel Institute, 28, Victoria Street, London, S.W.

FOR SALE AND WANTED.

FOR SALE, "Root's" Patent and other Foundry Blowers.
No. 2A size by "Daglish," Glasgow, 4½ in. outlet
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"Lloyd's" Patent Fan as new, 8 in. ,,
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LIME.—HYDRAULIC LIME suitable for concrete, also for building purposes, foundries and gas works.—THOS. MOAKES, Stanton Hills, Mansfield.

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CASTINGS.—For Good, Sound Machinery Castings, in Green or Dry Sand or Loam, up to 15 tons in weight, and Machined if required, apply to ROSE, DOWNS, AND THOMPSON, LTD., Old Foundry, Hull. Special Quotations for Quantities.

CRUCIBLE STEEL CASTINGS for Collieries, Works, and Engineers, from customers' patterns; machined if desired.—P. T. WOODRUFF AND CO., Machen, Newport, Mon.

FOR SALE, as a going concern, a Small Iron Foundry in London making a speciality. About £1,500 required for Plant, Goodwill, etc.—Every information given to a genuine intending buyer on application to Box 525, Offices of THE FOUNDRY TRADE JOURNAL, 165, Strand, London, W.C.

FOR SALE, Small Agricultural Engineering Works, comprising Blacksmith's Shop, Machine Shop, Foundry, etc. Valuation if preferred. Price £500—£600.—Apply IRONWORKS, St. Keyne, Cornwall.

JAMES DOUGALL & SONS, LTD.,
BONNYBRIDGE, N.B.
Foundry Specialists.
GANISTER, FIREBRICKS,
GANISTER BRICKS, FIRECLAY,
Of the Highest Qualities.
If you are troubled with Defective Fire-Resisting Materials write for Prices.
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NEWEST AND BEST WASH FOR STEEL FOUNDERS.
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Also Manufacturer of Fine Grade Coal Dust and Foundry Blackings.

COLD BLAST PIG-IRON.

M. & W. GRAZEBROOK,
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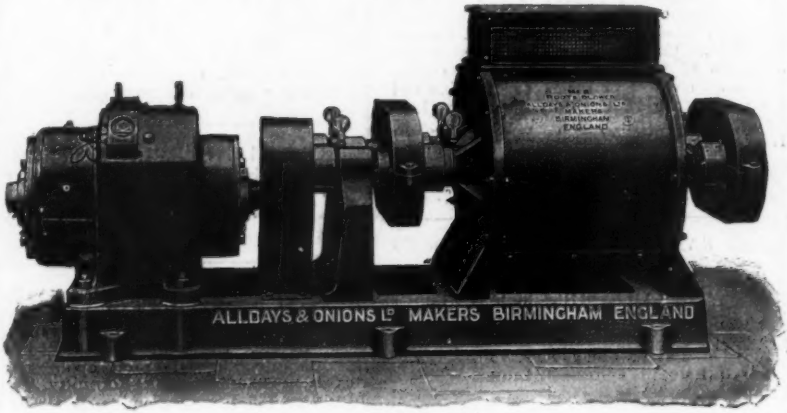

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DRIVEN BY STEAM, BELT, OR ELECTRICITY.

HORIZONTAL & VERTICAL.
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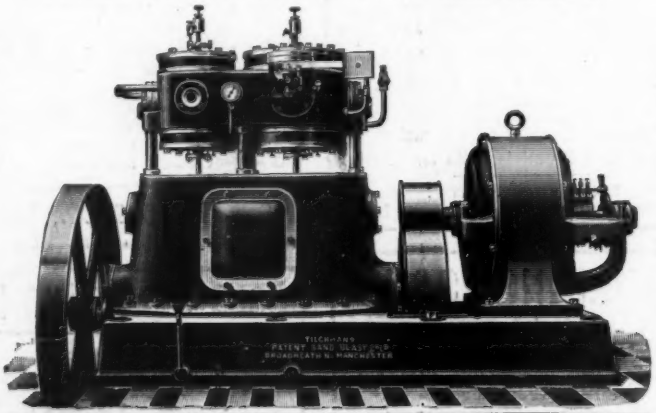

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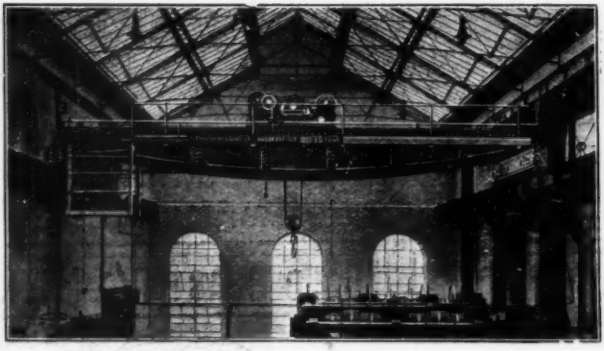

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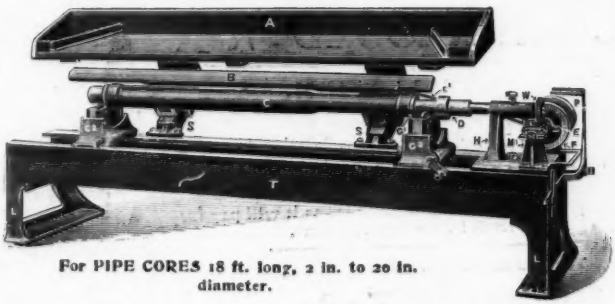

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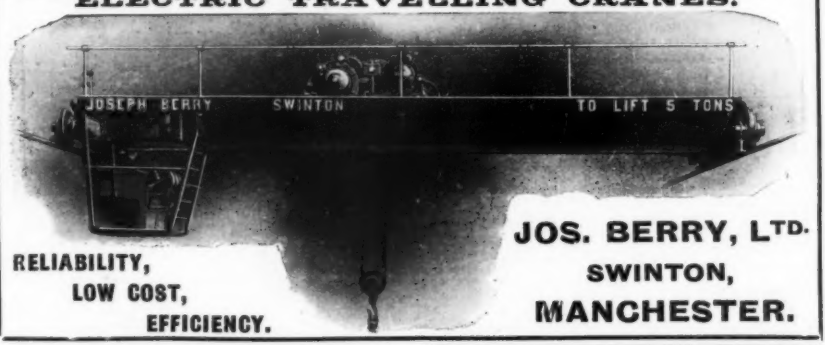

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NEWEST AND BEST WASH FOR STEEL FOUNDERS

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ALL OF THE BEST KIND.

Every works should possess one, as it will pay for itself in a very short time.

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SWIFT METALLIC STOPPING

THE NEW FOUNDRY CEMENT.

IT is used for filling up blow holes and sand holes in Cast Iron or Steel Castings.
IT is supplied in powder form and mixed for use with a little water to a stiff paste.
IT dries on a casting in 1 hour, and can be filed up bright in from 6 to 12 hours.
IT is specially useful to all Engineers, Machinists, Foundrymen, &c.
IT is of British Manufacture.

A Small Sample sent Post Free on receipt of your address, or a trial 1 lb. Tin Post Free on receipt of P.O. or Stamps for 1s. 6d.

THE SILENT MACHINE AND ENGINEERING CO., ALBION WORKS, SHEFFIELD.

Owing to GREATLY INCREASED DEMAND for our

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we have recently erected New Machinery to more than double our output.

SEND FOR PRICES AND SAMPLES.

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Cog Wheel Brand
Phosphor Bronze Alloys.
Phosphor Tin (5%).
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For High Temperatures.

Also Special Grades for
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38½"
McNEIL'S
PATENT UNBREAKABLE
STEEL LADLES
These Ladles are manufactured by a patented process, each from a single steel plate without weld or rivet. They are extremely light, being at the same time the strongest and most durable in the market. Ladles to contain 56 lb. of metal only weigh about 7 lb. each. They are made of all capacities from 30 lb. to 60 cwt., with or without lips; also mounted or unmounted. They are also suitable for chemical and metallurgical processes. List of sections and prices on application to
CHAS. McNEIL.
KINNING PARK IRONWORKS, GLASGOW.
36"
32½"

Can also be made in Aluminium.

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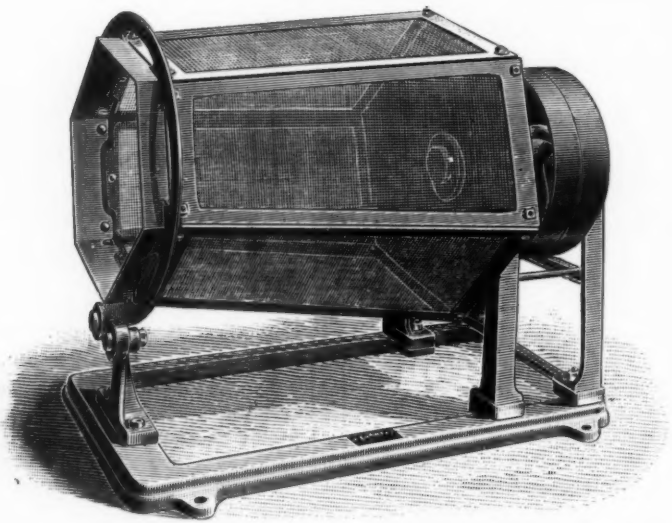

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Everything FOR THE Founders.

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